Quality Assurance Project Plan

Newfound Lake Watershed Assessment

Prepared for:

NHDES

Prepared by:

UNH CFB

and

University of New Hampshire Cooperative Extension

CFB Project Number: 2007-02-DES-01
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Quality Assurance Project Plan
Newfound Lake Watershed Assessment

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Date: June 4, 2007

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2.2 Document Control Format

The document control format is shown in the upper right hand corner of each page of this document.

2.3 Document Control Numbering System

A document control numbering system for all copies of this QAPP was not used because this project is of a small scale. The people who will receive copies of the QAPP are listed in Table 2 in Section 3.0.

2.4 EPA-NE QAPP Worksheet #2

All of the required elements of a project based QAPP have been covered in this document. The worksheet that follows on the next page has been annotated to indicate any deviations from the standard outline such as where sections have been combined due to the limited scope of field analysis and the resulting section number changes. It also indicates where a short narrative statement or bulleted list has taken the place of a formal table due to the limited scope of this project.

Table 1. EPA NE QAPP Worksheet #2

Required EPA QA/R-5 QAPP Elements	Required EPA-NE QAPP Elements and Corresponding EPA-NE QAPP Sections (Section Locations in this QAPP)	EPA-NE QAPP Worksheet #	Required Information (Table # in this QAPP) Note: strikethrough indicates information listed, but not as a table
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Measurement / Data Acquisition			
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Required EPA QA/R-5 QAPP Elements	**Required EPA-NE QAPP Elements and Corresponding EPA-NE QAPP Sections (Section Locations in this QAPP)**	**EPA-NE QAPP Worksheet #**	**Required Information (Table # in this QAPP)** Note: strikethrough indicates information listed, but not as a table
B2, B6 B7, B8	9.0 Sampling Procedures and Requirements 9.1 Sampling Procedures 9.2 Sampling SOP Modifications 9.3 Cleaning and Decontamination of Equipment/Sample Containers 9.4 Field Equipment Calibration 9.5 Field Equipment Maintenance, Testing and Inspection Requirements 9.6 Inspection and Acceptance Requirements for Supplies/Sample Containers	13 12b 14 15	-Sampling SOPs -Project Sampling SOP Reference Table (17) -Sampling Container, Volumes and Preservation Table (11) -Field Sampling Equipment Calibration Table (15) -Cleaning and Decontamination SOPs -Field Equipment Maintenance, Testing and Inspection Table (16)
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B4, B6 B7, B8	11.0 Field Analytical Method Requirements 11.1 Field Analytical Methods and SOPs 11.2 Field Analytical Method/SOP Modifications 11.3 Field Analytical Instrument Calibration 11.4 Field Analytical Instrument/ Equipment Maintenance, Testing and Inspection Requirements 11.5 Field Analytical Inspection and Acceptance Requirements for Supplies	17 18 19	-Field Analytical Methods / SOPs -Field Analytical Method / SOP Reference Table (17) -Field Analytical Instrument Calibration Table (15) -Field Analytical Instrument / Equipment Maintenance, Testing and Inspection Table (16)
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Required EPA QA/R-5 QAPP Elements	Required EPA-NE QAPP Elements and Corresponding EPA-NE QAPP Sections (Section Locations in this QAPP)	EPA-NE QAPP Worksheet #	Required Information (Table # in this QAPP) Note: strikethrough indicates information listed, but not as a table
B5	13.0 (12.0) Quality Control Requirements 13.1 (12.1) Sampling Quality Control 13.2 (12.2) Analytical Quality Control 13.2.1 (12.2.1) Field Analytical QC 13.2.2 (12.2.2) Fixed Laboratory QC	 22a 22b 23a 23b 24a 24b	Sampling -Field Sampling QC Table (18) -Field Sampling QC Table cont. (19) Analytical -Field Analytical QC Table (18) -Field Analytical QC Table cont.(19) -Field Screening/Confirmatory Analysis Decision Tree -Fixed Laboratory Analytical QC Sample Table (20) -Fixed Laboratory Analytical QC Sample Table cont. (20)
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3.0 DISTRIBUTION LIST

Table 2 presents a list of people who will receive the approved Quality Assurance Project Plan (QAPP), the QAPP revisions, and any amendments. A project personnel sign-off sheet is not included in this draft. It will be generated upon finalization of the QAPP, and all people related to the project will indicate they have read the QAPP before completing any analysis work on this project.

Table 2. QAPP Distribution List

QAPP Recipient Name	Project Role	Organization	Contact Information: Telephone Numbers and email Addresses
Jeffrey Schloss	Project Co-Manager/ Field Team Manager	UNH Center for Freshwater Biology/ UNH Cooperative Extension	(603) 862-3848 jeff.schloss@unh.edu
Robert Craycraft	CFB Laboratory Quality Assurance Officer/ Laboratory Manager		(603) 862-3696 bob.craycraft@unh.edu
Boyd Smith	Project Manager and Lead Volunteer Monitor	Newfound Lake Region Association	(603) 744-8689 Pemigwi@comcast.net
Jeff Merriam	UNH WQ Lab Quality Assurance Officer/ Laboratory Manager	UNH Dept. Natural Resources, WRRC	(603) 862-2341 jeff.merriam@unh.edu
Steve Landry	NH DES Project Coordinator	NH DES Watershed Management Bureau	(603) 271-2969 slandry@des.state.nh.us
Jillian McCarthy	NH DES Program Quality Assurance Coordinator	NH DES Watershed Management Bureau	(603) 271-8475 jmccarthy@des.state.nh.us
Vincent Perelli	NH DES Quality Assurance Manager	NH DES Office of the Commissioner	(603) 271-8989 vperelli@des.state.nh.us
Warren Howard	EPA New England Project Manager	EPA New England	(617) 918-1587 howard.warren@epamail.epa.gov
Charles Porfert	EPA New England Quality Assurance Officers	EPA New England	(617) 918-8313 porfert.charlie@epa.gov

(**BASED ON EPA-NE WORKSHEET #3**)

4.0 PROJECT ORGANIZATION

4.1. Project Responsibilities and Communication Pathways

Boyd Smith is the primary contact and project manager for the NH DES Watershed Assistance Grant provided to the Newfound Lake Region Association. Boyd is the executive director of the non-profit Newfound Lake Region Association in Bristol, New Hampshire**.** The UNH Center for Freshwater Biology (CFB) will perform the water quality monitoring work plan elements contained under the grant.

Jeff Schloss is the UNH CFB Project Manager and will act as the Project Co-manager for this investigation. He is responsible for coordinating specific details of the project and ensuring that the work completed by the UNH CFB meets the scope and objectives of the project. Professor Schloss will coordinate all aspects of the project including the sampling surveys, data analysis, report preparation and budget oversight. Professor Schloss will be working closely with all interested parties to formulate an effective sampling plan and solicit feedback regarding sampling efforts. The Project Manager will be responsible for resolving any logistical problems, stop/go decisions for sampling, and communicating the results to the field staff. He will also notify the respective labs as when to be prepared to receive samples.

Robert Craycraft is the UNH CFB Quality Assurance (QA) Officer and Laboratory Manager. His primary responsibility will be to ensure that data collected throughout this investigation meet the quality objectives set forth in this QAPP. During the study he will be responsible for conducting analyses according to the procedures in this QA Project Plan, identifying any non-conformities or analytical problems, and reporting any problems to the Project Manager. Working with the Project Manager, the Laboratory Manager will be responsible for resolving any analytical problems and communicating the results to the laboratory staff. At the end of this study the QA Officer will check, analyze and compile all QA/QC records and documentation. The QA Officer will be responsible for a memorandum to the Project Manager summarizing any deviations from the procedures in the QA Project Plan, the results of the QA/QC tests, and whether the reported data meets the data quality objectives of the project. The CFB Quality Assurance Officer, in conjunction with the CFB Project Manager, will also be responsible for training the CFB staff the applicable sample collection and water quality monitoring techniques required as outlined in this proposal.

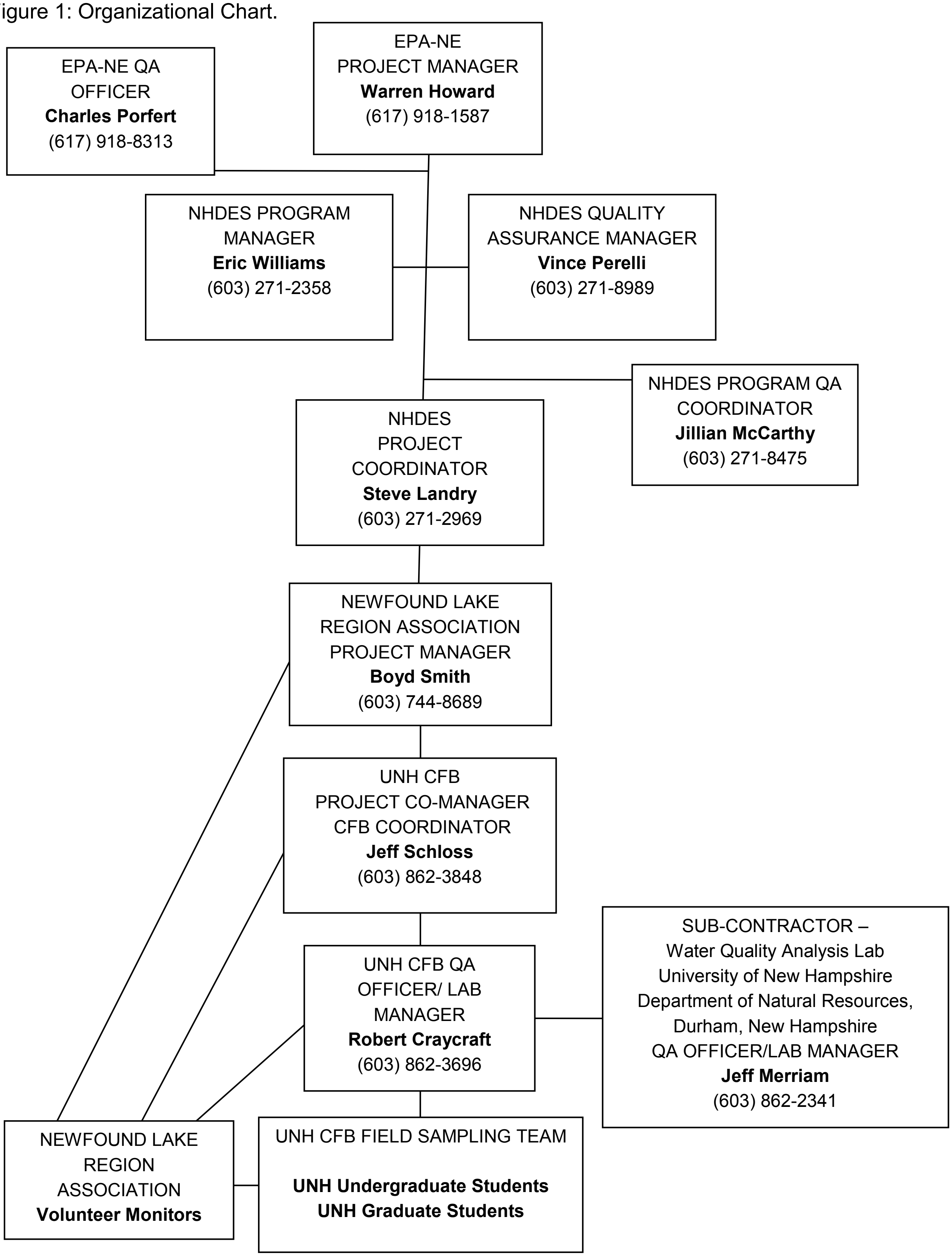
Field collections, field measurements and laboratory analysis as described in the work plan will be performed by the UNH CFB with the exception of the following analytical and sampling tasks. All anion and cation samples will be subcontracted through the Water Quality Analysis Lab of the University of New Hampshire Natural Resources Department under the direction of the Quality Assurance Officer and Laboratory Manager, Jeff Merriam. Newfound Lake volunteer monitors will assist in the collection and analysis of in-lake and tributary water quality samples that will be used to develop the Newfound Lake water/phosphorus budget.

Funding for this project is made available through a New Hampshire Department of Environmental Services (NHDES) watershed assistance grant. Warren Howard is the EPA New England project officer for the Newfound Lake Watershed Assessment Project (NLWAP). Steve Landry, the Merrimack watershed supervisor, is the project coordinator for the NHDES and is primarily responsible for working with the UNH Center for Freshwater Biology (UNH CFB) to ensure that the project scope is met. Jillian McCarthy and Vincent Perelli of the NHDES and an EPA New England Quality Assurance unit representative will review and approve the Quality Assurance Project Plan (QAPP) prior to project commencement.

The principal users of the data from this project will be the NHDES, the Newfound Lake Region Association and the Newfound Lake watershed Towns of Alexandria, Bristol, Bridgewater, Danbury, Dorchester, Groton, Hebron, Plymouth and Orange, New Hampshire. The data will also be made available to Plymouth State University and the Lakes Region Planning Commission to assist in long-term educational and regional planning initiatives. The Project Manager will submit project updates as well as a final report to the NHDES Project Coordinator at the end of the project with all the data and the QA Officer's summary report. Project results may also be of interest to co-occurring projects not covered by this QAPP including the study of water quality impacts due to the environmental impacts of urbanization.

Figure 1 is an organizational chart outlining the parties involved in this investigation and the communication pathways.

Figure 1: Organizational Chart.



4.2. Modification to Approved QAPP

The QAPP will be reviewed annually. If the sampling design, sample collection procedures, or data assessment and reporting change significantly, the UNH Project Coordinator will consult with the NH DES Project and QA Coordinators to submit modifications to EPA New England for approval.

4.3. Personnel Qualifications and Experience

Table 3 displays the personnel credentials of the Newfound Lake Watershed Project Team. Responsibilities have been discussed in more detail above.

Table 3. Personnel Qualifications and Experience

Name and Affiliation	Responsibilities	Education and Qualifications
Boyd Smith Newfound Lake Region Association Newfound Lake	Project Manager / Lead Volunteer Monitor	BS Geology, BS Hydrology Newfound Lake Region Association Executive Director
Jeffrey Schloss UNH Center for Freshwater Biology, Cooperative Extension Department of Zoology	Project Co-Manager / UNH CFB Project Coordinator	BS Marine Zoology; BA Economics MS Marine and Aquatic Biology PhD candidate; Extension Professor; Water Resources Specialist
Robert Craycraft UNH Center for Freshwater Biology Cooperative Extension	CFB Laboratory Manager/ QA Officer	BS Biology; Educational Program Coordinator NH Lakes Lay Monitoring Program
Jeffrey Merriam UNH Water Quality Analysis Laboratory Water Resources Research Center	Laboratory Manager/ QA Officer	BS Water Resource Management; MS Water Resource Management; Associate Director NH Water Resource Research Center
CFB Student Technicians	Lab and Field Support	Trained by Project Manager and Laboratory Manager
Newfound Lake Volunteers	Collect field samples	Trained by Project Manager and QA Officer

(Based on EPA-NE QAPP worksheet #6)

4.4. Training Requirements/Certification

Table 4 displays the project activities that require some level of training and the location where the training records will be compiled.

Table 4. Special Personnel Training Requirements Table

Project function	Description of Training	Training Provided by	Training Provided to	Location of Training Records
Stream Water Sampling	Water sample collection and analytical procedures / gauge reading	Jeff Schloss & Robert Craycraft	Newfound Lake Volunteers	CFB Laboratory
Lake Water Sampling	Water sample collection and analytical procedures	Jeff Schloss & Robert Craycraft	Newfound Lake Volunteers	CFB Laboratory
Lake Data Collection	Use of Profiling Instrumentation / Field data collection protocols	Jeff Schloss & Robert Craycraft	CFB Field Team Members	CFB Laboratory
Stream Data Collection	Measuring Streamflow	Jeff Schloss & Robert Craycraft	CFB Field Team Members	CFB Laboratory

(Based on EPA NE QAPP Worksheet #7)

Volunteers will initially be trained during a group training session where they will be certified in water sample collection, sample analysis, staff gauge reading and instructed on how to fill out the data sheet. A yearly refresher/recertification will occur through an annual workshop or one-on-one training depending on volunteer availability. See Section 6.1 II for additional information.

5.0 PROBLEM DEFINITION / BACKGROUND

This section documents the project planning, identifies the environmental problem, defines the environmental questions that need to be answered and provides background information.

5.1. Project Planning Meetings

In 2006, prior to submission of the grant proposal, a series of meetings were held to discuss the possible tasks that would better assess the current condition of Newfound Lake and that would help identify current threats and areas of concern that were related to increased development rates within the Newfound Lake watershed. The following persons attended the various meetings and provided guidance and discussion in shaping what was to become the conceptual foundation of an expanded water quality monitoring plan:

- Robert Craycraft, UNH Educational Program Coordinator
- Boyd Smith, Newfound Lake Region Association Executive Director
- Martha Twombly, Newfound Lake Region Association Program Director
- Bill Fay, Newfound Lake Region Association Board of Directors Member

The Newfound Lake Region Association, spearheading a larger watershed initiative, held two public meetings on July 31 and August 21, 2006 to explore the level of public support for the development of a watershed master plan. Over fifty stakeholders participated in the effort and the participants included municipal representatives from watershed towns, residents, condominium associations, local businesses and representatives from Plymouth State University and the University of New Hampshire. The stakeholders expressed a general theme of water quality protection and the need to expand water quality monitoring efforts into the near-shore locations as well as expand the water quality monitoring program further into the watershed to identify and document current and future threats to the lake. As a result of the watershed master plan meetings, a working group was designed to undertake a large-scale, watershed-wide planning initiative that includes a strong quantitative and scientifically-founded water quality component. Core members of the Watershed Master Plan working group include:

Steve Whittman - Jeffrey Taylor and Associates, Environmental Planner
Brian Eisenhower – Plymouth State University Faculty
Boyd Smith – Newfound Lake Region Association Executive Director
Robert Craycraft – University of New Hampshire Cooperative Extension Water Resources

The Watershed Master Plan Grant is designed to assist the towns in their long-term planning efforts that include a strong emphasis on protecting natural resources and water quality. The water quality monitoring component, outlined in this project, focuses on the continuation of long-term water quality data that will track both in-lake and tributary water quality. Tributary sampling will focus on the major tributary inlets that will quantify the surface water discharge and phosphorus loading into Newfound Lake, while supplemental sampling of impacted stream reaches will provide quantitative data that will further assess the impact of localized land use disturbances. A near-shore conductivity survey and accompanying *E. coli* sampling regime will help identify potential near-shore water quality variations and areas of potential concern while continued deep lake site sampling will be undertaken to expand upon the historical water quality database and to document Newfound Lake's trophic status during the course of this study. This project is being underwritten by a NH DES 2007 Watershed Assistance Grant.

5.2. Background

The Newfound Lake watershed is located in the Towns of Alexandria, Bristol, Bridgewater, Danbury, Dorchester, Groton, Hebron, Plymouth and Orange. With increased development pressures facing local decision-makers in the nine towns, there is an increased need for scientifically-based information on the impacts of development within the Newfound Lake watershed and the sub-watersheds that can be incorporated into a more pro-active watershed master plan to provide natural resource based planning guidance. The New Hampshire Department of Environmental Services (DES), in conjunction with the Newfound Lakes Region Association, completed a phosphorus budget for Newfound Lake in 1992 (Newfound Lake Region Association, 1996). The intent of the phosphorus budget was to provide a baseline data set that would be used for watershed planning. The 1992 Newfound Lake phosphorus budget identified a number of water quality measures that could be undertaken to minimize future water quality degradation, but lacked an implementation plan. As a result, development has continued within the Newfound Lake with little regard for measures, such as the retention of riparian buffers, minimization of impervious surface, etc., that would minimize water quality degradation. The current phosphorus budget is aimed at quantifying water quality changes that have occurred since the original phosphorus budget conducted in 1992 and the results of this study will be incorporated into a Watershed Master Plan that will be followed by a series of educational workshops directed at helping local municipalities implement measures that protect natural resources and more specifically, water quality.

The Newfound Lake Watershed Assessment Project will build on the water quality monitoring efforts that have been undertaken by the University of New Hampshire Center for Freshwater Biology and the New Hampshire Department of Environmental Services in conjunction with the Newfound Lake Region Association. The Watershed Master Plan Development and Implementation Grant recognizes the need for further monitoring and assessment within the watershed that can become part of a pro-active natural resource based planning initiative as stated in the grant application, *"…we offer a pro-active plan to improve land-use management practices and compliance, maintain water quality, and protect habitat"*. Furthermore, the integration of the water quality data into the overall Watershed Master Plan Development and Implementation Grant can be summarized by the following excerpt from the grant application:

"Results of summer 2006 public meetings indicate that long-term protection of water quality, natural habitat, and economic viability are of primary importance to stakeholders. Ideas to protect these resources include stewardship of natural resources through education and technical assistance, improved regulations and enforcement. The Watershed Master Plan (WMP) will help meet these

objectives through a collaborative process to increase local capacity for natural resource management. "

6.0 PROJECT / TASK DESCRIPTION AND SCHEDULE

6.1. Task Description

This project assists in the development of a pro-active, protective scheme for Newfound Lake and its watershed through an 18-month assessment of the primary tributary inlets by the UNH Center for Freshwater Biology (CFB) to discern the degree of nutrient input from the tributary inlets and to better understand the water quality variations among the Newfound Lake sub-watersheds. Additionally, targeted sampling of impaired stream reaches within the Newfound Lake watershed will be used to determine the impact of localized land use alterations. In-lake sampling will also be undertaken at seven historical "deep" sampling locations (Appendix H Maps) that will provide insight into variations among Newfound Lake's bays, coves and central sampling locations, while supplemental near-shore conductivity surveys coupled with an *E. coli* sampling regiment will provide insight into the impact of near-shore land use activities and the influence of watershed inputs as measured through near-shore sampling at the mouths of tributary inlets.

The in-lake and tributary monitoring components of this project will address the need to provide the towns with quantitative baseline data and to identify potential problems and areas of concern that can be used to better manage growth in the Newfound Lake watershed. The primary pollutant of concern is phosphorus (the lake stressor variable) in the context of how it will impact lake productivity as measured by chlorophyll concentration (lake reaction variable) while supplemental near-shore bacteria sampling will provide insight into public health concerns. Supplemental anion and cation data (i.e. sodium and chloride) will augment the assessment of impaired tributary reaches. All data collected through this project will assist in the creation of the Watershed Master Plan (aka Watershed Management Plan).

The Newfound Lake Watershed Assessment is designed to complete a series of independent, but interrelated objectives that will provide a better understanding of the impacts of development, population growth, and land use change on the Newfound Lake watershed. The Newfound Lake Watershed Master Plan and Implementation Grant includes the following tasks that will collectively be used to help develop the Watershed Master Plan based upon sound scientific data:

- Prepare a Quality Assurance Project Plan (task I)
- Train Project Staff (task II)
- Train Volunteer Stream and Lake Monitors (task III)
- Complete an 18-month Newfound Lake Water/Phosphorus Budget (task IV)
- Conduct In-lake Sampling (task V)
- Conduct Near-shore Conductivity Surveys and Collect *E. Coli* Samples (task VI)
- Continue Newfound Lake Tributary Sampling (task VII)
- Perform a Nested Watershed Study of Select Stream Reaches (task VIII)
- Prepare Final Reports, and Meet with the Watershed Master Plan Steering Committee (task IX)

I. Prepare Quality Assurance Project Plan

A QA Project Plan for the Newfound Lake in-lake and tributary sampling will be produced by UNH and approved by the NHDES and EPA New England before any field sampling on this project begins. This QAPP uses a combination of elements from previously accepted QAPPs written by UNH and approved by NHDES and EPA New England, guidance documents from the US EPA and EPA New England web sites and example QAPPs provided by NHDES. The in-lake and tributary field sampling methodologies are based on sampling methods outlined in previously approved QAPPS for Lake Winnipesaukee, Mendums Pond, and Chocorua Lake, while the laboratory analytical procedures are based on well accepted methods outlined in standard method manuals (APHA 1998, USEPA 1999) or are based upon methods that have previously been approved in an EPA New England accepted QAPP for similar water and nutrient budget studies conducted by the NHDES, the UNH CFB, or other NH investigators.

II. Train Project Staff

The CFB Project Manager will organize and implement a training session for field and laboratory staff. The training session will cover SOPs for field data collection, field instruments, and field data sheets. The training will be based on the QA Project Plan document. Field staff and lab staff will sign an attendance sheet for the training. The training will be completed before field sampling begins. Refresher training (re-training) will be offered at the start of each sampling year.

III. Train Volunteer Monitors

The CFB Project Manager will organize and implement a training session for volunteer monitors. The training session will cover SOPs for field sampling, sample processing and filling out field data sheets. The training will be based on the QA Project Plan document. Volunteer monitors will sign an attendance sheet for the training. The training will be completed before field sampling begins. Refresher training (re-training) will be offered at the start of each sampling year.

IV. Newfound Lake Water/Phosphorus Budget

Rationale: The eighteen-month tributary study is designed to determine the Newfound Lake phosphorus loading that occurs through surface water inputs. The tributary study is a follow up on a 1992 Newfound Lake Phosphorus Budget (Newfound Lake Region Association 1996) which set a baseline for investigating water quality change with progressing watershed development. The proposed water/phosphorus budget will provide insight into the impacts of increased residential growth pressures that are occurring within the Newfound Lake watershed and that have altered the landscape since the initial Newfound Lake tributary study was undertaken. The results of this study will provide better natural resource management strategies that can be incorporated into the Watershed Master Plan and subsequently into the master plans, local regulations and into growth management strategies employed by the Towns of Alexandria, Bristol, Bridgewater, Danbury, Dorchester, Groton, Hebron, Plymouth and Orange. Monitoring of the previous study's sampling stations that represent perennial tributary inlets, and the Newfound Lake outlet (see Table 9 and maps in Appendix H for all designated monitoring sites), will allow for the comparison and change detection to take place. In addition, additional tributary sampling sites have been added to account for additional sources of channelized flow into Newfound Lake. Sampling will be done by volunteers, UNH faculty, and UNH students to track the total phosphorus, specific conductivity, temperature, turbidity, dissolved oxygen and pH. The sampling design allows us to document the water volume and phosphorus loading that occurs in each of the major Newfound Lake sub-watersheds and the outlet tributary. The study period will span approximately eighteen months, and annual total phosphorus loading values will be formulated over the twelve-month period where the most consistent data (at least two samplings per month and relatively normal weather conditions for that month) have been collected. The Newfound Lake Tributary Study will facilitate lake management at the watershed scale and will allow targeted educational and mitigative efforts at the sub-watershed scales where the identified problems and concerns are most pressing. Outreach products from this project will involve the Newfound Lake Region Association, the watershed community, concerned citizens, the Newfound Area School District and local decision-makers.

Sampling Tasks: Physical and chemical water quality samples and staff gauge readings will be collected by the volunteer monitors in the tributary inlets and in the Newfound Lake outlet on an approximate weekly basis to document the short-term fluctuations in the discharge volumes and phosphorus loading. The proposed sample locations are discussed below, listed in Table 9 and indicated on the maps in Appendix H. Staff gauges have been positioned in the twenty-three tributary inlet locations and at the Newfound River (dam outlet) and have been selected based on accessibility and stream bottom composition. Relatively flat-bottomed portions of the stream with unobstructed flow have been selected for staff gauge installation. All stream samples will be collected near the gauged sites. Approximate weekly water quality sampling will be undertaken by trained volunteers who will completely fill out a field sampling sheet record: the staff gauge height, stream temperature, specific conductivity, dissolved oxygen and pH measurements and collect total phosphorus and turbidity samples. Monthly water quality measurements will be collected by the University of New Hampshire CFB field team to include temperature, dissolved oxygen, specific conductivity, turbidity, pH, staff gauge height readings, stream morphology and stream velocity measurements. The CFB field team will complete a field data sheet at each sampling location, make recordings in a field log notebook and will collect total phosphorus samples for laboratory analysis. Storm event sampling will also be conducted by the CFB field team during a minimum of two major storm events that represent conditions when the phosphorus loading tends to be most severe in our New Hampshire watersheds.

A minimum of two high intensity storm events will be selected during which all twenty-four tributaries will be monitored by CFB field technicians to document the physical and chemical conditions during those events. The sampling will be conducted during an intense period of the storm event during which rainfall and runoff have greatly exceeded base flow conditions.

Analysis Tasks: Stream temperature, dissolved oxygen and specific conductivity measurements will be measured in-situ throughout the monitoring period while stream water samples will be collected and analyzed in the laboratory for total phosphorus, pH and turbidity. Discharge measurements will be calculated based on the stream channel dimensions and/or culvert dimensions, water depth and the concurrent stream flow measurements. Discharge calculations will be based on standard hydrological calculations (width * depth * velocity along a transect across the stream channel) and a rating curve shall be developed to calculate the discharge volumes for each sampling site. Laboratory analyses will be performed in the CFB laboratory and will include Total Phosphorus (TP) analysis, through persulfate digestion, turbidity analysis using a portable Turbidimeter, and pH by electrometric probe.

V. In-Lake Sampling

Rationale: In-lake water quality data will add to the long-term database and facilitate further trend detection, will allow for the determination of the phosphorus loading to lake-phosphorus concentration relationship, will help assess Newfound Lake's trophic status, and will quantify the degree of internal nutrient loading. The data will be incorporated into the Newfound Lake water/phosphorus budget.

The in-lake, deep sampling stations will follow the seven historical sampling locations for which a long-term database has been developed (Table 10 and Maps in Appendix H). The seven deep sampling stations represent locations that range from a centrally located open water sampling station at the deepest point in Newfound Lake that reflect the integration and cumulative impacts occurring to the lake, to sampling locations in bays and near major tributary inlets which reflect more localized water quality variations among sampling locations. Sampling will be performed by volunteers, UNH faculty and UNH students and will include the collection of physical, chemical and biological data that will be used to discern whether variations exist among the sampling locations and among the thermal layers at the respective sampling location.

Sampling Tasks: In-lake sampling will be conducted by the volunteer monitors on a weekly to bi-weekly basis between the months of June and September to document short-term water quality variations that occur from week to week. The volunteer monitors will collect temperature profiles, Secchi Disk transparency measurements and composite water quality samples for chlorophyll *a*, true color, total alkalinity and total phosphorus analysis at each sampling station. The CFB field team will collect samples on a monthly basis between the months of May and September, during which New Hampshire lakes typically become thermally stratified. The CFB field team will collect vertical water quality profiling data that will include depth, temperature, dissolved oxygen, specific conductivity, oxidation reduction potential, pH, turbidity, chlorophyll *a* (estimated via fluorescence) and underwater irradiance. Water quality chemistry data will also be collected as point samples in the epilimnion, metalimnion, and hypolimnion that shall include total phosphorus, chlorophyll *a* (measured spectrophotometrically), true color, alkalinity, carbon dioxide and dissolved oxygen measured via the Winkler Method. An epilimnetic composite sample will be collected for the analysis of total phosphorus, alkalinity, chlorophyll *a* and true color at each sampling site while Secchi Disk transparency measurements, phytoplankton samples and zooplankton samples will also be collected at each in-lake sampling station to screen for potentially noxious algal forms such as cyanobacteria species and to document the dominant planktonic forms. See Table 13 for the rationale of the selection for each of the parameters measured in this study.

Analysis Tasks: In-lake sampling will include the collection of point and composite water samples that will be analyzed for chlorophyll *a* and true color through spectrophotometric detection, alkalinity, carbon dioxide and dissolved oxygen (QC of probe) by titration. In-situ data will include temperature, dissolved oxygen, pH, specific conductivity, oxidation reduction potential and chlorophyll fluorescence profiles by multi-parameter electronic probes while underwater irradiance will be measured with a submersible photometer. In-lake biological analyses will include the identification and enumeration of phytoplankton and zooplankton samples. Laboratory analyses will be performed in the CFB laboratory and will also include Total Phosphorus (TP) analysis, through persulfate digestion, performed on both point and composite water samples.

VI. Near-shore Conductivity Surveys and *E. coli* sampling

Rationale: Near-shore water quality variations can be associated with localized water quality problems and localized nutrient inputs that may include localized variations in land use practices and inputs from watershed sources through tributary inlets.

The Center for Freshwater Biology field team will conduct shoreline conductivity surveys between the spring and fall months in 2007 and 2008 to identify potential “hot-spots” where future water quality monitoring efforts should be directed. A total of thirty sampling stations will also be designated as standard sampling locations where bacteria, total phosphorus and sampling will be conducted to document the in-lake conditions during and following heavy storm events, as well as the conditions that follow a heavy period of shoreline use such as the fourth of July weekend or the Labor Day weekend (Table 11 and Maps in Appendix H). The 30 pre-designated sampling locations will help develop a base-line that will provide insight into both the natural near-shore water quality variability as well as the identification of suspect near-shore locations where future educational and corrective efforts should be focused.

Sampling Tasks: Center for Freshwater Biology field staff will collect temperature and specific conductivity measurements using a YSI 85 meter and Global Positioning System coordinates while slowly trolling around the periphery of Newfound Lake. Data will be recorded on field data sheets and will also include field observations. Should unusually high conductivity readings be measured, the field technician will also collect an *E. coli* and total phosphorus sample. *E. coli*, total phosphorus, and specific conductivity samples, as well as field observations, will also be collected at 30 pre-designated sampling locations.

Analysis Tasks: Temperature and specific conductivity measurements will be measured in-situ at each designated sampling location, while *E. coli* will be analyzed using a membrane filtration technique, and total phosphorus analysis will be performed through persulfate digestion and subsequent spectrophotometric analysis.

VII. Newfound Lake Tributary Sampling (Post Water Nutrient Budget Monitoring)

Rationale: In-stream water quality will vary dependent upon natural factors (i.e. rainfall quantity and rainfall intensity) as well as anthropogenic factors. The Newfound Lake tributary sampling focuses on follow-up sampling, upon completion of the Newfound Lake water/phosphorus budget data (task IV), in order to document longer-term water quality and to continue to track water quality variations among sampling locations and to further characterize the condition of the Newfound Lake sub-watersheds.

Sampling Tasks: Physical and chemical water quality samples and staff gauge readings will be collected by the volunteer monitors in the tributary inlets and in the Newfound Lake outlet on an approximate monthly basis to document fluctuations in the discharge volumes and phosphorus loading. The proposed sample locations were previously identified under task IV, are listed in Table 9 and indicated on the maps in Appendix H. All stream samples will be collected from near the gauged sites. Approximate monthly water quality sampling will be undertaken by trained volunteers who will completely fill out a field sampling sheet, record the staff gauge height, stream temperature, specific conductivity, dissolved oxygen and pH measurements, and collect total phosphorus and turbidity samples. Two water quality sampling trips will be conducted by the University of New Hampshire CFB field team to include temperature, dissolved oxygen, specific conductivity, turbidity, pH, staff gauge height readings, stream morphology and stream velocity measurements. The CFB field team will complete a field data sheet at each sampling location, make recordings in a field log notebook and will collect total phosphorus samples for laboratory analysis.

Analysis Tasks: Stream temperature, dissolved oxygen, and specific conductivity measurements will be measured in-situ throughout the monitoring period while stream water samples will be collected and analyzed in the laboratory for total phosphorus, pH and turbidity. Discharge measurements will be calculated based on the stream channel dimensions and/or culvert dimensions, water depth and the concurrent stream flow measurements. Discharge data will be compared to the rating curves developed as part of the Newfound Lake water/phosphorus budget (task IV) and discharge calculations will be based on rating curves previously developed and shall be used to calculate the discharge volumes for each sampling date unless the previously developed rating curves are proven invalid. Laboratory analyses will be performed in the CFB laboratory and will include Total Phosphorus (TP) analysis, through persulfate digestion, turbidity analysis using a portable Turbidimeter, and pH by electrometric probe.

VIII. Nested Watershed Study of Select Stream Reaches

Rationale: Rural communities, such as those that comprise the Newfound Lake watershed, are oftentimes characterized by localized water quality problems that may not be evident when water quality sampling is restricted to larger stream and river courses where the localized impacts are masked by groundwater recharge and “purified” runoff that enters the water course through forested drainages. The approach will consist of both a paired-watershed approach (impaired and reference sampling locations) combined with an upstream/downstream approach (aka. nested watershed approach) to further characterize the localized anthropogenic impacts and how the water quality changes as the streams are influenced by differing watershed inputs. These data will be instrumental in helping local decision makers understand the impacts of localized practices that could result in wide-spread water quality deterioration if left unabated.

Sampling Tasks: Physical and chemical water quality samples and measurements will be collected during, or immediately following heavy storm events, when the sediment and nutrient loading tends to be most severe. An attempt will be made to collect the water sample during the most intense period of each storm event. Proposed sampling stations in each stream reach will represent an upstream (minimally impaired) site, a second “impacted” site located in the impairment zone and a third site downstream of the impairment zone (Table 12 and Maps in Appendix H). Sampling will include the collection of total phosphorus, soluble reactive phosphorus, anion (sulfate, nitrate and chloride) and cation (sodium, potassium, magnesium and calcium), pH and turbidity data. Temperature, dissolved oxygen and specific conductivity measurements will also be collected.

Analysis Tasks: Temperature, specific conductivity and dissolved oxygen measurements will be measured in-situ. Total Phosphorus (TP) analysis, through persulfate digestion, soluble reactive phosphorus (SRP), turbidity and pH analyses will be performed in the CFB laboratory. The anion and the cation data will be contracted through the University of New Hampshire Water Quality Analysis Laboratory.

IX. <u>Submit interim reports, prepare a Final Report, and meet with Watershed Master Plan Committee.</u>

Semi-annual updates will be provided by e-mail to the NHDES Project Coordinator. The final work products will be presented in the form of summary reports that will include an Excel spreadsheet containing quality assured results of the analyses that were collected as part of the Newfound Lake water/phosphorus budget and as part of a second report that summarizes both the near-shore and the tributary data collected as detailed in this QAPP. Included with the data will be a metadata listing to allow the project data to be available for uploading to STORET and the NHDES Environmental Monitoring Database (EMD) or similar data warehouses administered by NHDES and or EPA. The QA/QC data will also be included and summarized in the respective reports. The following reports will be included / provided:

- A Newfound Lake water/phosphorus budget summary report.
- A Newfound Lake report that summarizes all water quality data collected as part of this project, identifies potential problem areas and include a section on Newfound Lake’s trophic status.

Educational outreach meetings and workshops among the UNH Project Manager the UNH Quality Assurance Officer, members of the watershed master plan committee, local officials and residents from the Towns of Alexandria, Bristol, Bridgewater, Danbury, Dorchester, Groton, Hebron, Plymouth and Orange (that compose the Newfound Lake watershed) will also take place to discuss project results at a time convenient for the watershed community.

6.2. Project Schedule

Table 5 summarizes the tasks listed above and includes the projected schedule to complete them.

Table 5. Anticipated Project Schedule.

Task	Anticipated Dates of Initiation and Completion	Responsible Persons / Group	Products	Rationale
QAPP Development	February 2007 – June 2007	UNH Project Manager and UNH QA Officer	Draft QAPP	NH DES and EPA QAPP approval required for grant
QAPP Approval	June 2007	NH DES and EPA QA Officers	QAPP	To help ensure data collected will meet QA/QC standards
Staff Training	June 2007 – ongoing as needed	UNH Project Manager and Lab Manager	NA	QA/QC, preferred field practices, safety
Stream Sampling : **Year 1** [1] **Year 2**	 June 2007 – December 2007 January 2008 – December 2008	UNH CFB	Physical and chemical data summaries	Collect discharge data and accompanying physical and chemical measurements that will be used to quantify the water and phosphorous load that will culminate in the Newfound Lake water/phosphorus budget.
Lake Sampling: **Year 1** [1] **Year 2**	 June 2007 – September 2007 May 2008 – October 2008	UNH CFB	Annual physical, chemical and biological data summaries	Collect vertical profile data, Secchi Disk transparency data and point physical, chemical and biological samples.
Near-shore Conductivity Survey and *E. coli* Sampling **Year 1** **Year 2**	 June 2007 – October 2007 May 2008 – October 2008	UNH CFB	Annual physical, chemical and biological data summaries	Collect specific conductivity, total phosphorus and E. coli data from shallow water areas around the Newfound Lake shoreline to screen for potential problem areas and develop a near-shore water quality database.
Paired Tributary Study	June 2007 – November 2008	UNH CFB	Annual physical and chemical data summaries	Collect total phosphorus, soluble reactive phosphorus and accessory physical and chemical data to quantify water quality degradation associated with impaired stream reaches.
Final Reports to NH DES **Phosphorus/Nutrient Budget** **Water Quality Assessment**	 Ongoing – April 2008 Ongoing – March 2009	UNH Project Manager	Reports	Produce summary reports for distribution among the working group members.
Meetings/ Outreach Events (not under scope of grant UNH will assist at no charge)	Ongoing, upon request	UNH Project Manager and UNH QA Officer	Meetings/ Outreach Materials	Meetings and workshops will be held to summarize the results of the water/phosphorus budget and the water quality assessment.

(Based on EPA- NE Worksheet #10.)

[1]- Refers to data that will be used to complete an ongoing Newfound Lake Water/Phosphorus Budget. Existing data that will be used to develop the Newfound Lake water/phosphorus budget are described in Table 21.

6.3. Summary of Analysis Tasks

Tables 6A and 6B present a breakdown of who will be responsible for sample analysis and field work. Anion and cation data (Nitrate-N, Calcium, Magnesium, Sodium, Potassium, Chloride and Sulfate) will be filtered, as outlined in Appendix D.4, to avoid contamination and blockage of the analytical instrumentations which relies on an ion exchange column and tubing with a fine pore size and a small inner diameter.

Table 6A. - Laboratory analytical services table

Analyte	Laboratory contact or instrument and person responsible
Matrix / Lab Analysis	
Stream Water: (unfiltered) Total Phosphorous Soluble Reactive Phosphorus	UNH Center for Freshwater Biology Analytical Lab (CFB) UNH Spaulding Hall G-18 Durham, NH 03824 Robert Craycraft, Lab Manager (603) 862-3696 bob.craycraft@unh.edu
PH	Hanna Instruments model HI 9025 pH meter w/ Beckman Star® Series Low Ionic Strength combination pH probe (Part #511071)
Turbidity	LaMotte 2020e Turbidimeter
Alkalinity	UNH CFB Titration Test Kit (.002N H_2SO_4)
Stream Water: (filtered) Nitrate-N Calcium Magnesium Sodium Potassium Chloride Sulfate	Water Quality Analysis Lab (WQA) University of New Hampshire Department of Natural Resources, James Hall Durham, NH 03824 Jeff Merriam QA Officer/Lab Manager (603) 862-2341 jeff.merriam@unh.edu
Lake Water:	
Total Phosphorous	UNH CFB Laboratory (see above)
Total Alkalinity	UNH CFB Titration Test Kit (.002N H_2SO_4 titrant)
Chlorophyll *a*	Spectrophotometric analysis via Std. Meth. 10200 H.2
Dissolved "true" Color	Spectrophotometric analysis via Std. Meth. 2120B
Free Carbon Dioxide	Titration via Std. Meth. 4500-CO2 C.
Dissolved Oxygen	Winkler Titration via Std. Meth. 4500-O C. to QA electrical DO probe
E. coli	Membrane filtration via Std. Meth. 9213 D.2,3
Phytoplankton	Utermohl Technique, Std. Meth. 10200 F
Zooplankton	Microscopy via Std. Meth. 10200 G

(Based on EPA-NE Worksheet #9d)

Table 6B. – Field analytical services table

Analyte	Laboratory contact or instrument and person responsible
Matrix / Field Analysis	
Stream Water:	
Temperature, Dissolved Oxygen and Conductivity	YSI Model 85 Temperature/Dissolved Oxygen/Conductivity Meter
Stream Velocity	YSI SonTek Flowtracker Handheld ADV
Lake Water:	
Temperature, Dissolved Oxygen, Oxidation Reduction Potential, pH, Specific Conductivity, Turbidity and Chlorophyll *a*	YSI 6600 Sonde fitted with: • YSI Model 6562 Dissolved Oxygen Probe • YSI Model 6560 Conductivity/Temperature Probe • YSI Model 6565 Combination pH/ORP Probe • YSI Model 6136 Turbidity Probe • YSI Model 6025 Chlorophyll Probe *
Underwater Irradiance	Li-Cor LI-1400 data logger, L193 submersible cell and L191deck cell
Zooplankton	Aquatic Research Instruments 64um mesh plankton net; Dissecting Microscopy at 80x magnification.
Phytoplankton	Aquatic Research Instruments Van Dorn, Inverted Microscopy at 400x magnification.
Secchi Disk	Lawrence Enterprises Limnological Secchi Disk
	Person responsible for training: CFB Project Manager (Schloss) Person responsible for equipment: CFB Lab Manager (Craycraft)

(Based on EPA-NE Worksheet #9d)

* Chlorophyll data will be obtained through *in vivo* flourescence detection using the YSI Model 6025 probe. The chlorophyll estimates obtained through *in vivo* flourescence will be compared to chlorophyll *a* concentrations obtained through organic solvent extraction and subsequent spectrophotometric analysis to determine whether the fluorescence derived chlorophyll data are a good indicator of the in-lake chlorophyll *a* concentrations.

7.0 DATA QUALITY OBJECTIVES FOR MEASUREMENT DATA

7.1. Project Data Quality Objectives (DQOs)

This project is designed to quantify the nutrient load and water load into Newfound Lake to help identify potential problem areas within the watershed and to summarize Newfound Lake's trophic status. Thus, the level of data quality must ensure that field collection and sample processing will allow the proper characterization of the phosphorus and water loading values. The proposed water sampling design described above will yield sufficient data for this purpose. Precision, accuracy/bias, quantitation limits, and completeness of data are addressed in Section 7.2 below.

The CFB will analyze the accumulated results to make recommendations for follow-up research and potential control strategies that will mitigate existing and future pollutant sources.

7.2. Measurement Performance Criteria for Water Quality Measurements

An overview of the measurement performance criteria to be used in this study for water samples is listed in Table 7 and explained in more detail below it. The specific performance criteria goals and related information for each analyte/measurement are listed in Table 8.

Table 7. Measurement Performance Criteria Used for Water Quality Measurements

Data Quality Indicators	Measurement Performance Criteria	QC Sample and/or Activity Used to Assess Measurement Performance
Precision-Overall	RPD	Field Duplicates
Precision-Lab	RPD	Lab Duplicates
Accuracy / Bias	RPD % R (Yield) r^2	Certified Reference Materials Laboratory Fortified Matrix Spikes Standard Calibration Curve
Comparability	Measurements should follow standard methods that are repeatable	All project personnel will review QAPP and receive training / Signed record of such.
Sensitivity	MDL	Yearly (at minimum) Method Detectable Limit Calculation
Completeness	Number of samples meeting data quality objectives	Data Completeness Check
Contamination	≤ Laboratory Quantitation Limit	Field Blanks Lab Blanks

(Based on EPA NE Worksheet #11b)

Precision

Precision is the degree of agreement among repeated measurements of the same characteristic on the same sample or on separate samples collected at the same time and location. Precision will be assessed as the relative percent difference between duplicate measurements taken in the field, and the relative percent difference between duplicate samples created in the lab. Duplicate measurements will also be made for each field parameter measured.

The relative percent difference (RPD) will be calculated as follows:

$$RPD = \left(\frac{|x_1 - x_2|}{\frac{x_1 + x_2}{2}} \right) \times 100$$

where the equation numerator is the absolute value of the difference between duplicates.

RPD will be calculated for each sampling visit. The desired field and lab precision data are reported in Table 8. For the CFB in-lab nutrient analyses all samples are run as duplicates and any discrepancies for a sample above the stated precision requires a re-run of that sample (unless the average of the two samples is less than 10X the MDL). For the WQA laboratory duplicates (unless otherwise noted on Tables 6 and 7), a difference greater than 10% requires further investigation of the sample run. A difference greater than 15% is failure (unless the average of the two samples is less than 10X the MDL), and results in reanalysis of the entire sample run, unless there is a reasonable and supported explanation for the inconsistency. When field duplicates are analyzed and exceed the RPDs outlined in Table 8, the non-compliant samples will be considered suspect and the non-compliant samples will be re-run. If the second run does not fall within the allowable range, the data will be flagged as unacceptable and the sampling and handling protocols will be investigated further.

Accuracy

Accuracy or percent error is the degree of agreement between the observed value (i.e., measured, estimated, or calculated) and an accepted reference or true value (i.e., the real value). Laboratory accuracy will be measured through spiked samples, prepared controlled samples, instrument blanks or certified reference materials as appropriate for individual methods. Frequency and selection of accuracy measurement depends on methods. To create a spike sample, a field collected sample will be divided into two portions (aliquots). A known amount of standard is added (spiked) to one of the aliquots. Both aliquots are then analyzed and the amount of the spiked material recovered is compared to the amount added using the following equation:

$$\%R = \frac{(Spiked\ sample - Original\ sample)}{(Spiked\ amount)}\ x\ 100$$

Total phosphorus samples processed in the CFB lab that are paramount to the Newfound Lake water/phosphorus budget will be assessed for accuracy at a frequency of 10% of all samples run, or one per analytical batch, whichever is more frequent.

As pH is a logarithmic scale, and buffered solutions are the certified reference solutions used for pH, that accuracy will be expressed as the difference between the measured value and the value expected from the certified reference standard in pH units. Certified reference samples are also used in most of the nutrient and ion analytical runs as individual standards or combined standards. When reporting accuracy in these cases (in addition to or as an alternative to spiked samples) the following formula will be used for percent recovery (using a blank for the matrix):

$$\%R = \frac{(Result\ for\ Analyte\ in\ Certified\ Reference\ Material)}{(Verified\ Amount\ of\ Analyte\ in\ Certified\ Reference\ Material\ from\ Vendor)}\ x\,100$$

A third accuracy check involves the regression results of the certified reference standards commonly included in each analytical batch. In these cases, the r^2 value of the standard regression is to be reviewed.

Representativeness

Representativeness is a qualitative term that describes the extent to which a sampling design adequately reflects the environmental conditions of a site. The primary goal of the Newfound Lake phosphorus/nutrient budget is to quantify the phosphorus load into Newfound Lake. The collection of weekly total phosphorus samples, as well as supplemental storm event samples, as weather patterns dictate, will allow us to document the annual range of conditions and use these data to determine the annual phosphorus load into Newfound Lake.

Comparability and Sensitivity

Comparability is important since the data obtained will be used as an indication of what similarities and difference exist among the Newfound Lake tributary inlets and among the in-lake sampling locations. Thus, data collection and data analysis will be done in a similar way to previous studies. The sensitivity of the methods is important to be able to yield the results at the level necessary to perform this comparison.

Maintaining consistency with SOPs and using standardized sampling methods will achieve comparability among samples. Samples will be collected in a consistent way throughout the study and all samples will be processed within the specified holding times. In regard to sensitivity, tributary loadings have previously been studied in Newfound Lake as part of the 1992 joint Department of Environmental Services/Newfound Lake Region Association phosphorus budget. Comparability of data will be important to determine whether or not the results of this project fall within what has previously been documented as part of that phosphorus budget or if significant change has occurred in any sub-watershed, and if so, can it be explained.

Completeness

The completeness of the database is a critical aspect of data quality and data usefulness. We expect, at the minimum, to collect weekly sampling for each of the 24 tributary sampling sites over the final seven months (672 tributary total phosphorus samples plus QA samples) of an 18 month study. This assumes no logistical or unaccounted complications such as atypically dry conditions during which there is no water in the stream channels, culverts or dam outflow. We also plan to collect additional samples during the runoff season and major storm events at the minimum for three additional sites. A completeness of 80% of all samples planned, or at least 2 samples per month per site when flow is evident, is the minimum requirement established for the Newfound Lake phosphorus/nutrient budget component of this project. We also intend to follow the quality control and assurance procedures stated in this QAPP. An additional goal is to have obtained 100% of the planned QC samples; however, 90% completeness for QA samples will be considered acceptable.

Contamination

Field decontamination procedures (detailed in Section 9.3 below) and sampling and lab methodology SOPs (appendices) are designed to limit sample to sample contamination and check for instrument drift. A check on those processes will involve the use of lab and field blanks that will be taken at the end of each field sampling session (after decontamination procedures are followed) and for each lab assay run. In the field, distilled, deionized (DDI) water will be “collected” as the actual samples were and processed as a field sample. In the lab, the proper blank matrix will be used.

Table 8. Data Quality Objectives for the Water Matrix Samples

Analyte (Sample Source)	SOP Method	Desired Precision	Desired Accuracy	Analytical / Achievable Method Detection Limit[1]	Analytical / Achievable Laboratory Quantitation Limit[2]	Typical Measurement Range
Laboratory Analysis						
Total Phosphorus (Stream and Lake Water)	Appendix A.3	RPD ≤ 20% (Field) RPD ≤ 10% (Lab)	90-110% RPD ≤ 10% $r^2 \geq 0.995$	0.8 *µ*g/L	2.0 *µ*g/L	2 – 500 *µ*g/L P
Soluble Reactive Phosphorus (stream)	Appendix A.2	RPD ≤ 20% (Field) RPD ≤ 10% (Lab)	90-110% RPD ≤ 10% $r^2 \geq 0.995$	0.3 *u*g/L	1.0 *u*g/L	1 – 500 *u*g/l P
Turbidity (Stream Water)	Appendix B.9	RPD ≤ 5% (Field) RPD ≤ 5% (Lab)	+/- 1.0 NTU	0.01 NTU	*NA*	0 – 50 NTU
pH (Stream Water)	Appendix B.1	RPD ≤ 0.2 std units (Field)	+/- 0.2 pH units	*NA*	0.1 pH units	2 –12 pH Units
Total Alkalinity (Lake Water)	Appendix B.2	RPD ≤ 15% (Field)	85 - 115%	0.2 mg/L	0.5 mg/L	0.5 – 20 mg/L $CaCO_3$
Carbon Dioxide (Lake Water)	Appendix A.9 (titration)	RPD ≤ 15% (Field) RPD ≤ 10% (Lab)	85 - 115%	0.2 mg/L	0.5 mg/L	0.5 – 30 mg/L
Dissolved Oxygen (Lake Water)	Appendix A.10 (titration)	RPD ≤ 10% (Field) RPD ≤ 5% (Lab)	85 - 115%	0.2 mg/L	0.5 mg/L	0.5 – 15 mg/L
Chlorophyll	Appendix A.8	RPD ≤ 10% (lab)	+/- 15% of Turner Standard	*NA*	*NA*	0 – 50 *µ*g/L
E. Coli	Appendix A.11	RPD ≤ 20% (Field) RPD ≤ 10% (Lab)	0 counts/100 ml (sterilized blank)	*NA*	*NA*	0 – 500 CFU/100ml

Analyte (Sample Source)	SOP Method	Desired Precision	Desired Accuracy	Analytical / Achievable Method Detection Limit[1]	Analytical / Achievable Laboratory Quantitation Limit[2]	Typical Measurement Range
Field Analysis (stream water and near-shore lake sampling)						
Temperature	Appendix B.5	+/- 0.2^{o}C	+/- 0.2^{o}C	NA	NA	0 - 30^{o}C
Specific Conductivity	Appendix B.5	RPD ≤ 5%	+/- 5%	NA	NA	0 - 1000 μS/cm
Dissolved Oxygen	Appendix B.5	RPD ≤ 5%	+/- 0.3 mg/L	NA	NA	0 – 20 mg/L
Stream Velocity/Depth	Appendix B.7	RPD ≤ 10%	+/- 1%	NA	NA	0 – 50 CFS
Field Analysis (lake water profiling by YSI 6600 Sonde)						
Depth	Appendix B.8	RPD ≤ 5%	+/- 0.12 m	0.01 m	NA	0-20 m
Temperature	Appendix B.8	RPD ≤ 5%	+/- 0.15^{o}C	NA	NA	0 – 30^{o}C
Dissolved Oxygen	Appendix B.8	RPD ≤ 5%	+/- 2% of reading	0.1 mg/L 0.1%	NA	0 – 15 mg/L
Specific Conductivity	Appendix B.8	RPD ≤ 5%	+/- 5%	0.5μS / cm	NA	0 – 1000 μS/cm
pH	Appendix B.8	RPD ≤ 5%	+/- 0.2 units	NA	NA	0 – 12 pH Units
Oxidation Reduction Potential (ORP)	Appendix B.8	RPD ≤ 5%	+/- 20 mV	NA	NA	-100 – 400
Turbidity	Appendix B.8	RPD ≤ 5%	+/- 0.2%	NA	NA	0 – 50 NTU
Chlorophyll	Appendix B.8	RPD ≤ 15%	+/- 20%	NA	NA	0 – 50 μg/L
Underwater Irradiance	Appendix C	RPD ≤ 10%	R^2 > .95 (with depth)	NA	NA	0 – 2500 μE/cm
Supplemental Analysis of Tributary (stream) samples						
Nitrate Nitrogen (stream water)	Appendix D	RPD ≤ 20%(Field) RPD ≤ 15% (Lab)	85-115%	0.003 mg/L	0.05 mg/L	0.05 – 10 mg/L N
Sodium (stream water)	Appendix D	RPD ≤ 20%(Field) RPD ≤ 15% (Lab)	85-115%	NA	0.1 mg/L	0.1 – 15 mg/L Na
Potassium (stream water)	Appendix D	RPD ≤ 20%(Field) RPD ≤ 15% (Lab)	85-115%%	NA	0.05 mg/L	0.05 – 7 mg/L K
Magnesium (stream water)	Appendix D	RPD ≤ 20%(Field) RPD ≤ 15% (Lab)	85-115%	NA	0.1 mg/L	0.1 – 7 mg/L Mg
Calcium (stream water)	Appendix D	RPD ≤ 20%(Field) RPD ≤ 15% (Lab)	85-115%	NA	0.1 mg/L	0.1 – 10 mg/L Ca
Chloride (stream water)	Appendix D	RPD ≤ 20%(Field) RPD ≤ 15% (Lab)	85-115%	0.02 mg/L	0.2 mg/L	0.2 – 15 mg/L Cl
Sulfate (stream water)	Appendix D	RPD ≤ 20%(Field) RPD ≤ 15% (Lab)	85-115%	0.04 mg/L	0.1 mg/L	0.1 – 8 mg/L SO_4

(Based on EPA NE worksheet 9b and 9c)

1 Method Detection Limit (MDL) is the minimum concentration of a substance that can be measured and reported with 99% confidence that the analyte concentration is greater than zero.

2 Quantitation limit for samples analyzed in the Water Quality Analysis Lab are based on user experience and previous analysis (not statistically calculated); those used by the CFB Analytical Lab are calculated as 2.5 to 10 times the MDL for analyses depending on the method and familiarity with routine method performance

8.0 EXPERIMENTAL DESIGN (SAMPLING PROCESS DESIGN)

8.1. Rationale for Design

As stated previously, the purpose of our investigation is to perform a phosphorus/nutrient budget for Newfound Lake and to summarize the water quality findings with specific emphasis on Newfound Lake's trophic state and threats to Newfound Lake water quality.

We plan to address the following specific goals:

a. Analyze the physical and chemical characteristics of the major tributary inlets and the tributary outlet of Newfound Lake. Particular emphasis will be placed on the characterization of the stream channel morphology and the stream velocity, as well as the analysis of total phosphorus, temperature, specific conductivity, pH and turbidity.
b. Conduct in-lake water quality testing at the seven historical deep sampling basins to better understand the lake's trophic state. In-lake profiling will be undertaken at each deep site and will include depth, temperature, dissolved oxygen, specific conductivity, oxidation reduction potential, pH, chlorophyll and turbidity measurements. Point and composite water quality samples will also be collected for zooplankton, phytoplankton, total phosphorus, chlorophyll a, true color, and alkalinity.
c. Perform near-shore conductivity surveys and collect total phosphorus and *E. coli* samples to screen for potential problem areas around the periphery of Newfound Lake and to expand upon the in-lake database.
d. Conduct a paired stream reach study to identify and quantify localized water quality problems within the Newfound Lake watershed, which if left unattended, will ultimately culminate in more severe water quality problems that will impact Newfound Lake.
e. Produce a phosphorus/nutrient budget that will be packaged as a document that contains summary text, a complete data listing, graphical display of data and maps and images that depict the sampling locations.
f. Produce a water quality assessment report that summarizes potential threats and problem areas in and around Newfound Lake and summarize the Newfound Lake trophic status.

This QAPP outlines our intended sampling strategy and analytical procedures to meet these goals.

8.2. Field Sampling Rationale

(See also rationale discussion in section 6.1 above) Sampling is planned for June 2007, following final EPA QAPP approval, through early November 2008 and can be summarized with two overarching objectives that will culminate in summary reports that will be submitted to DES. The Newfound Lake tributary inlets, and outlet, will be monitored on an approximate bi-weekly basis to obtain the data necessary to calculate the phosphorus and water load to Newfound Lake. Supplemental storm event sampling will also be undertaken to augment the weekly data and to provide additional insight into the variations in nutrient load that occur during base flow and peak flow periods. More frequent data might be collected during the spring runoff period and following heavy storm events (storms predicted at greater than 2.0"/day), and sampled approximately 1 to 2 hours after the start of the storm to further refine the Newfound Lake water/phosphorus budget but shall be undertaken at the discretion of the CFB Project Manager. Lake data collected during the months of May through September will provide additional insight into the lake's current state of eutrophication, and may also provide important insight into the Lake's response to nutrient loading that occurs over the course of this study.

8.2.1. Choice Of Study Streams

The study streams have been selected to include all appreciable sources of channelized surface water into, and out of Newfound Lake. The study streams include those streams that were sampled and are reported in the 1992 Newfound Lake phosphorus budget (Table 9). The stream gauging/monitoring locations have been selected close to the lake edge to assure all watershed inputs to the respective streams are accounted for. However, the CFB field team also ensured that the stations are set far enough upstream from the lake edge to avoid the influence of lake effects, which may cause back-flushing into the stream. The CFB is also evaluating four additional upstream sites that will provide further insight into the nutrient loading that occurs in the larger tributary inlets, the Fowler River and the Cockermouth River, that constitute over 75% of the Newfound Lake watershed. The supplemental upstream sampling will facilitate further sub-watershed phosphorus loading calculations in these high priority drainages.

Table 9. Newfound Lake Study Streams.

Study Streams	Site ID	Location: Latitude Longitude	Sampling Site Description	Stream Sampled in DES Study	Rationale/ Comments
Hemlock Brook	NLRA T01	43°37'51.4" 71°44'09.3"	Junction of Sunset Drive and Route 3A.	Yes	The Tributary sampling locations were selected to ensure all major sources of channelized flow entering and leaving Newfound Lake would be quantified in terms of discharge and phosphorus load. Discharge and phosphorus loading calculations in un-gauged sub-watersheds, where distinctive tributaries do not exist, shall be modeled using
Tilton Brook	NLRA T02	43°38'15.8" 71°44'09.1"	Near Junction of Route 3A & Whittemore Pt. Road South.	Yes	
Dick Brown Brook	NLRA T03	43°39'28.4" 71°44'14.7"	Near Junction of Route 3A & Whittemore Pt. Road North.	Yes	
Whittemore Brook	NLRA T04	43°39'58.8" 71°44'41.8"	Near Junction of Route 3A, Paradise Road and Brook Road	Yes	
Wilson Brook	NLRA T05	43°40'43.0" 71°45'52.4"	Across from Favor Road at the Camp Pasquaney wooden walking bridge.	Yes	
Yellow Brook	NLRA T06	43°41'19.1" 71°46'14.5"	At junction of Onaway Point Road and Route 3A. Down Onaway Point Road as culvert passes under the road.	Yes	
Post Office Brook	NLRA T07	43°41'28.7" 71°46'11.7"	Adjacent to Merrill Road off of Route 3A.	Yes	
Barn Brook	NLRA T08	43°42'54.5" 71°46'08.7"	Off Route 3A next to address #49.	Yes	
Cashman Brook	NLRA T09	43°42'09.3" 71°46'31.8"	At junction of Cooper Road and Stony Brook Road	Yes	

Study Streams	Site ID	Location: Latitude Longitude	Sampling Site Description	Stream Sampled in DES Study	Rationale/ Comments
Georges Brook	NLRA T10	43°42'19" 71°46'30"	At the junction of Cooper Road and Georges Brook	Yes	the areal phosphorus loading values from the most similar gauged watershed(s) to avoid errors that can arise when un-gauged watersheds are grouped or "lumped" into gauged watersheds.
Cockermouth River (near lake)	NLRA T11	43°41'39.9" 71°47'47.2"	At the junction of North Shore Road & the Cockermouth River	No	
Cockermouth River (upstream)	NLRA T12	43°41'49.4" 71°48'28.8"	At the intersection of Braley Road and the Cockermouth River	Yes	
Tannery Brook	NLRA T13	43°42'40.7" 71°49'33.7"	Groton Road adjacent to the Hebron Public Safety Building	No	
Cockermouth River (upstream)	NLRA T14	43°42'14.1" 71°49'59.8"	Groton Road adjacent to the Groton Town Offices	No	
Hebron Brook	NLRA T15	43°41'29.7" 71°48'14.7"	Hebron Brook intersection with Cross Road.	Yes	
Kendall Brook	NLRA T16	43°40'48.6" 71°47'34.7"	Approximately 0.5 miles north of Camp Wicosuta. The stream is next to an house with an open field	Yes	
Mason Brook	NLRA T17	43°40'17.7" 71°47'38.2"	At Camp Wicosuta off of West Shore Road	Yes	
The Ledges	NLRA T18	43°39'36.1" 71°47'33.7"	At the Ledges condominium development off of West Shore Road	No	
Wellington Brook	NLRA T19	43°38'27.2" 71°46'52.6"	Near Bristol/Alexandria Town line & near trailhead parking. Down access road by Park Ranger Station	Yes	
Fowler River	NLRA T20	43°37'58.1" 71°46'28.1"	Fowler River at the intersection with West Shore Road.	Yes	
Bog Brook	NLRA T21	43°37'28.5" 71°46'29.0"	At the intersection of Fowler River Road and Bog Brook	No	
Fowler River (upstream)	NLRA T22	43°37'41.0" 71°47'34.4"	As the Fowler River intersects Fowler River Road	No	
Black Brook	NLRA T23	43°37'40.2" 71°45'22.7"	Junction of Brown's Beach Road & West Shore Road	Yes	
Newfound River	NLRA T24	43°37'06.1" 71°44'20.8"	At the junction of West Shore Road and Old Route 3	Yes	

8.2.2. Choice Of In-Lake Sampling Stations

Seven in-lake sampling locations have been selected on Newfound Lake that have been included in past sampling efforts undertaken by the CFB and the NH Lakes Lay Monitoring Program, and have been documented in the annual volunteer monitoring reports provided since 1986 (LLMP 1986-2006). The seven sampling sites are positioned at the deeper points around Newfound Lake. The lake sites reflect localized water quality variations found among the more centrally located sampling stations in both the open waters, and more confined basins, around Newfound Lake (Table 10). The monitoring of the seven in-lake sampling locations will also provide insight into the differences, and similarities among the sites that could be important when considering future remedial actions for the lake, as well as, the susceptibility of the seven Newfound Lake sampling stations to water quality degradation. Furthermore, during the period of thermal stratification, Sites Deep and Mayhew can effectively function as two “independent lakes” where the chemical, physical and biological characteristics can potentially exhibit appreciable variation.

Table 10. Newfound Lake Study Sites

Lake Sites	Site ID	Location: Latitude Longitude	Sampling Site Description / Rationale
Deep	NLRA L01	43°39’24.7” 71°46’24.5”	Deepest Point in Newfound Lake, reflects the overall condition of Newfound Lake
Mayhew	NLRA L02	43°37’24.5” 71°44’16.5”	Southern Lake basin with heavy first-tier lakeshore development that might impact water quality.
Pasquaney Bay	NLRA L03	43°39’41.8” 71°44’42.1”	Sampling station located in Pasquaney Bay where watershed runoff might impact local water quality.
Loon Island	NLRA L04	43°41’49.3” 71°46’43.8”	Sampling station located in the northeasterly bay. Water quality will reflect sub-watershed inputs.
Cockermouth	NLRA L05	43°41’22.5” 71°47’24.0”	Sampling station located in the northwesterly bay that is “fed” by the Cockermouth River. Water quality will reflect the Cockermouth River drainage and other local watershed inputs.
Beachwood	NLRA L06	43°40’23.3” 71°47’09.1”	Sampling station located along the westerly shoreline.
Follansbee Cove	NLRA L08	43°38’40.7” 71°46’55.6”	Sampling location located in a westerly basin located near Wellington state park. Water quality will reflect the sub-watershed inputs.

8.2.3. Precipitation/Evaporation Data

Rainfall data will be obtained from the Newfound Lake Dam discharge and climate sampling station operated by the New Hampshire Department of Environmental Services to obtain ambient rainfall measurements that will be used to develop the Newfound Lake water/phosphorus budget. Supplemental precipitation and climatological data will be obtained from National Oceanic and Administration National Climate Data Center sampling stations located in the town of Alexandria for comparative purposes and to ensure daily data, necessary for this study, are available. Supplemental data will also be obtained from the Massabesic Lake climatological sampling station to provide estimates for evaporation rates that are not recorded at either the Meredith or Plymouth climatological sampling stations.

8.2.4. Near-shore Sampling Locations

Near-shore sampling stations will be identified that correspond to locations that are most susceptible to water quality variations, such as areas near tributary inlets and areas near more intensive land use, as well as a series of reference sampling locations that reflect minimal levels of anthropogenic influence. *Note: near-shore sampling locations will be identified and listed in Table 11 following a field reconnaissance in May and June 2007*. The near-shore sampling location data will be augmented with supplemental near-shore conductivity survey data and, when potential problem areas are identified as specific conductivity spikes, the CFB will also collect accessory *E coli*, and total phosphorus samples for analysis.

8.2.5. Nested Watershed Study

A nested watershed design, a.k.a. an "above-and-below" design will be used to evaluate the impact of localized land use alterations on select stream reaches within the Newfound Lake watershed. Stream reaches will represent those areas that are likely being impacted by anthropogenic activities and areas that remain unchanged to serve as "controls". During a pre-conference workshop at the 14th Annual Enhancing the States' Lake Management Programs, Davenport et. al. (April 17, 2001) suggested pre/post watershed studies should optimally include both an upstream/downstream and paired watershed component to the study. The proposed Newfound Lake Watershed Assessment will employ such an approach to best assess the impact of intensive land use (i.e. clear cutting, agriculture, sloping lawns, impervious surfaces) by monitoring upstream/downstream of the impaired stream reach. Paired watersheds will then control for the effects of hydrologic variation and account for the natural water quality variations. We intend to collect runoff samples from four stream reaches that represent two impaired streams and two reference streams. Each stream will be sampled on a total of five wet weather sampling dates and the samples will be collected during or immediately following periods of heavy precipitation.

The wet weather sampling will be limited to precipitation events during which the rainfall totals a minimum of ½ inch over a 24 hour period, while at least one of the storm sampling events be conducted during storm events characterized by ¾ inches of rainfall over a 24 hour period which is considered the threshold for significant overland runoff (Hewlett, 1982),. A minimum antecedent dry period of 24 hours will be required between any two successive storm sampling events. Storm event sampling may include the period of spring melt, when the ground is saturated and minimal vegetative cover is available to intercept water and particulate debris, the wet summer and fall periods where heavy periods of rainfall over the past several days/week have raised the groundwater table and will translate into increased stream-flow, as well as, the drier summer months that are generally characterized by a lower water table and reduced groundwater recharge that coincide with increased evapotranspiration rates as dictated by the ambient weather conditions.

Table 11. Near-shore Study Sites (*Note:* *near-shore sampling locations will be identified and listed below following a field reconnaissance in May and June 2007)*.

Site ID	Location: Latitude	Location: Longitude	Sampling Site Description	Sampling Rationale
NLRA S01	TBD			Near-shore sampling locations were selected to include areas that are heavily influenced by watershed sources, such as sites near the mouths of tributary inlets, areas impacted by intensive land use and areas that represent least impaired “reference” conditions. The data will be used to document localized water quality variations that respond to both natural and human induced variables, and that will facilitate sound management strategies to mitigate problem areas and pro-actively work towards avoiding future problems.
NLRA S02	TBD			
NLRA S03	TBD			
NLRA S04	TBD			
NLRA S05	TBD			
NLRA S06	TBD			
NLRA S07	TBD			
NLRA S08	TBD			
NLRA S09	TBD			
NLRA S10	TBD			
NLRA S11	TBD			
NLRA S12	TBD			
NLRA S13	TBD			
NLRA S14	TBD			
NLRA S15	TBD			
NLRA S16	TBD			
NLRA S17	TBD			
NLRA S18	TBD			
NLRA S19	TBD			
NLRA S20	TBD			
NLRA S21	TBD			
NLRA S22	TBD			
NLRA S23	TBD			
NLRA S24	TBD			
NLRA S25	TBD			
NLRA S26	TBD			
NLRA S27	TBD			
NLRA S28	TBD			
NLRA S29	TBD			
NLRA S30	TBD			

Table 12. Nested Design Sampling Stations (*Note:* *nested design sampling locations will be identified and listed below following a field reconnaissance in May and June 2007)*.

Stream	Site ID	Location: Latitude	Location: Longitude	Sampling Site Description	Rationale
TBD (stream 1)	NLRA-P01				Sampling locations have been selected to represent sites that are being impacted by anthropogenic activities and areas that remaine unchanged to serve as "controls". Additional sampling of upstream and downstream locations in a given stream further evaluates the impact of localized pollutant loading in the respective stream.
TBD (stream 1)	NLRA-P02				
TBD (stream 1)	NLRA-P03				
TBD (stream 2)	NLRA-P04				
TBD (stream 2)	NLRA-P05				
TBD (stream 2)	NLRA-P06				
TBD (stream 3)	NLRA-P07				
TBD (stream 3)	NLRA-P08				
TBD (stream 3)	NLRA-P09				
TBD (stream 4)	NLRA-P10				
TBD (stream 4)	NLRA-P11				
TBD (stream 4)	NLRA-P12				

8.3. Rationales for Parameters Measured and Samples Taken

Table 13 summarizes the various rationales for including the different measurements.

Table 13. Sampling Parameters and Rationale

Sampling Parameters	Rationale
Total Phosphorus	Phosphorus (P) tends to be the limiting nutrient in lakes. Total phosphorus is the sum of phosphorus in all its forms and can be used to determine a lake's trophic state. Quantifying the phosphorus load is of paramount importance in lake management.
Precipitation	Precipitation will influence the amount of overland runoff and groundwater recharge and can be correlated to nutrient and sediment loading episodes. Precipitation quantities will be needed to complete the Newfound Lake water/phosphorus budget.
Turbidity	Turbidity reflects the amount of particulate matter and will provide some insight into whether the "total phosphorus" is entering the lake in a particulate or dissolved form. Turbidity will also serve as an indicator of areas within the watershed where sediment erosion is of the greatest concern.
Temperature	Temperature is correlated to what types of aquatic organisms can survive in the lake and the streams. Temperature variations can also reflect differences in the amount of riparian cover in the Newfound Lake sub-watersheds.

Sampling Parameters	Rationale
Specific Conductivity	Specific Conductivity will provide an insight into local geological variations among the sampling stations, as well as provide insight into regions where road salt runoff, nutrient runoff, etc. might be impacting the water quality.
Total Alkalinity	Alkalinity is generally low in New Hampshire Lakes and provides insight into the susceptibility of Newfound Lake to acid precipitation.
pH	An indicator of acid loading, pH also influences nutrient availability from the sediments and impacts the fitness and distribution of aquatic organisms.
Dissolved Oxygen	Dissolved oxygen concentrations are essential for a healthy fishery and are also associated with the eutrophication process. Anoxic conditions are commonly associated with internal nutrient loading in many New Hampshire lakes.
Oxidation Reduction Potential (ORP)	ORP profiles in Newfound Lake will be used to determine whether the chemical conditions are conducive to internal nutrient loading and if so, how the in-lake chemistry may vary from April to November.
Secchi Disk Transparency	Water transparency integrates the impacts of sediments, algal cells, true color and detrital debris that are flushed into the lake. The Secchi Disk transparency measurements will provide water transparency data that can be compared to historical transparency data.
Chlorophyll *a*	Chlorophyll a serves as a good estimator of algal biomass. The collection and analysis of chlorophyll samples are relatively simple and will provide insight into the trophic condition of Newfound Lake.
True Color	True color can have a significant impact on the water clarity, particularly in localized areas of the Newfound Lake watershed where considerable wetland drainage exists. True color measurements provide insight into the causes of water transparency variations as well as insight into the seasonal variations in the amount of wetland drainage into Newfound Lake.
Zooplankton	Zooplankton are near the base of the food chain and are important from the standpoint of assessing the ecological integrity of a system. Zooplankton also act as a biological control of phytoplankton and knowledge of their composition is an element of lake management
Phytoplankton	Phytoplankton abundance and diversity is correlated to the nutrient load and other physical and chemical variables. Knowledge of the phytoplankton population will provide additional insight into the condition of Newfound Lake.
Underwater Irradiance	Light measurements will help determine whether there are significant physical and biological variations vertically throughout the water column.

Sampling Parameters	Rationale
E. coli	*E coli* data will be used to screen for fecal contamination that can be an indication of potential problem areas around Newfound Lake.
Anions/Cations: Nitrate ($NO3^{-}$) Chloride (Cl^{-}) Sulfate ($SO4^{-2}$) Sodium (Na^{+}) Potassium (K^{+}) Magnesium (Mg^{+2}) Calcium (Ca^{+2})	For the nested watershed study; will provide a quantitative assessment of nutrient and salt loading that includes nitrates, sodium and chloride, which are oftentimes associated with intensive land use practices.

9.0 SAMPLING METHOD PROCEDURE REQUIREMENTS

9.1. Sampling Procedures

The requirements for the type of container used to collect water samples are based on the chemical analysis conducted, and the use of preservative (Table 14). See Table 17 for method description.

Table 14. Sampling Method Requirements for Water Samples

Parameter	Sample Matrix/ Collection Method	Collected Sample Volume	Sample Holding Container[1]	Preservative	Maximum Holding Time
Alkalinity	Water; grab	250 ml	250 ml Opaque HDPE[1] plastic	On ice	<8 hours
pH[1]					
Carbon Dioxide					
Turbidity					
Dissolved Oxygen	Water; grab	300 ml	300 ml Wheaton glass BOD bottle	On ice w/ manganous sulfate, alkali-iodide-azide and H_2SO_4	<8 hours
Chlorophyll *a*	Water; grab & composite	2 liter	2 l Opaque HDPE plastic	On ice	< 8 hours[2]
True color					
Phytoplankton					
Zooplankton	Vertical net haul	400 ml	500 ml wide mouth plastic HDPE	Formalin sucrose solution	< 6 months
Total Phosphorus	Water; grab & composite	250 ml	Individual 250 ml Plastic HDPE for each	Acidified w/ H_2SO_4 to pH <2 / iced in field / frozen within 8 hours of sample collection	<90 days[3]
Ortho-Phosphate [6]	Water; grab	250ml	Individual 250 ml Plastic HDPE for each	Filtered [4] / iced / and refrigerated at 4°C	< 7 days
Cations/Anions [6]: Nitrate, Sodium, Potassium, Sulfate Magnesium, Calcium, Chloride	Water; grab & composite	55 ml	60 ml Plastic HDPE	Filtered / iced / frozen within 8 hours of sample collection	Indefinite[5]
E *coli*	Water; grab	500 ml	Sterilized 500 ml Whirl-Pack bag	On ice	< 8 hours

(Based on EPA NE Worksheet 12b)

[1] HDPE-High Density Polyethylene. PH samples will be qualified as being analyzed in the laboratory within eight hours of sample collection.

[2] Chlorophyll and color samples are filtered within eight hours of sample collection and the color samples are then refrigerated with a seven day holding time and the chlorophyll a samples are frozen with a 28 day holding time. The phytoplankton samples are collected in 40 ml Histoplex containers within 8 hours of collection, preserved with Lugol's solution, refrigerated and quantified microscopically within six months of preservation.

[3] Expected target holding times are indicated for nutrient analysis; however documentation in the literature on unacidified samples (Canfield et al 2002) and UNH CFB analyses on acid preserved samples have shown samples remain stable for over 150 days.

[4] Ortho-phosphate samples will be field filtered using a Nalgene filterholder receiver and a Nalgene hand pump. 250 milliliters of streamwater will be filtered through a 0.45 micron HAWP 04700 Millipore membrane filter and the filtrate will be transferred to a 250 milliliter acid washed sampling bottle and immediately placed on ice. Orthophosphate samples will be held for a maximum of seven

days at 4°C and orthophosphate samples that are not analyzed within 48 hours of data collection shall be qualified as exceeding a two day holding period.

[5] The UNH WQA lab will usually process these samples within 3 months of receipt. However, their documentation and references state "indefinite" as a maximum holding time and is consistent with maximum holding times reported in previously EPA NE approved QAPPs for this lab with similar data quality objectives to this study.

[6] Samples that are frozen prior to analysis shall be flagged and a qualifier shall be included in the final data summary that identifies the samples that were frozen.

The standard operating procedures for field sampling are provided in Appendices B and C. Appendix D contains the QA Plan for the UNH Water Quality Analysis Laboratory. This document describes the general SOPs for the laboratory. This QA plan has been included with other QAPPs that have been approved by EPA New England for projects with similar data quality objectives.

9.2. Sampling SOP Modifications

It is not expected that any modification of sampling will occur. However, corrective action in the field may be needed if the sampling strategy needs to be modified (i.e., sampling additional sample locations other than those specified in the QAPP, not enough water sample to meet original requirements, etc.), or when sampling procedures and/or field analytical procedures require modification, due to equipment failure or unexpected conditions. In general, the field team may identify the need for corrective action on-site. The field staff, in consultation with the UNH Project Manager (or if absent, the senior field technician), will evaluate and suggest a corrective action. The field team will implement the corrective action. Any modifications/corrective actions will be noted on the field data forms. The UNH QA Officer will be notified as soon as possible and will provide the field team with any additional actions required to maintain quality assurance and control with respect to corrective actions. It will be the responsibility of the UNH Project Manager to ensure the corrective action has been implemented correctly and reported to the NHDES Project Manager and QA Officer, and the EPA New England QA Officer. If any of the aforementioned QA Officers have additional actions recommended to maintain quality assurance and control they will be implemented retroactively, if possible, and for any sampling events after the event that triggered the corrective action.

9.3. Cleaning and Decontamination of Equipment / Sample Containers

Prior to use, all samplers and tools will be vigorously cleaned with a phosphorus free detergent (i.e., Alconox) and rinsed generously with distilled water. Between deployments and between sites the samplers will be scrubbed and rinsed three times with distilled water. All sample containers for nutrients will be washed in an acid bath (10% HCL) and triple rinsed with deionized (Millipore Milli Q System) distilled water (DDI water). All other sample containers will be washed in Alconox and triple rinsed in DDI water. As the transfer of potentially invasive species is of concern, all biological materials will be washed off of equipment, gear, clothing and carrying cases while on-site. No decontamination by-products of any consequence are expected to be generated in the field. SOPs for cleaning and decontamination can be found in Appendices A, B and D.

9.4. Field Equipment Calibration

Field Equipment will be calibrated in accordance with the manufacturer calibration directions as listed below and as summarized in Table 15:

The Hanna Instruments model HI 9025 pH meter with a Beckman Star® low ionic strength combination electrode shall be calibrated on the day of measurement using the built in calibration process and pH 7 and pH 4 buffers according to the manufacturers directions. After calibration the probe will be rinsed three times with DDI water and placed in a beaker of lake surface water for at least 5 minutes to condition the probe for measurement. Two DDI water rinses and blotting with a KimWipe ® tissue will be done between sample readings. Following all sample analyses for a batch, a new sample of 7.0 pH buffer will be measured and the results will be recorded on the field sheet.

The LaMotte 2020e Turbidimeter will be calibrated immediately prior to use in accordance with the suggested manufacturer's calibration procedures using calibration solutions of 0.1 and 20 NTU. Following calibration, the LaMotte 2020e Turbidimeter will remain on all day, or until all samples have been analyzed. The glass turbidity cells shall be rinsed three times with DDI water between samples and the exterior of the cell shall be wiped with a Kimwipe by placing circling the cell with the Kimwipe and, while holding the Kimwipe against the glass vial, the cell will be rotated by twisting the "cap" to produce a minimum of 10 cycles. Past CFB analysis has indicated that this vial wiping approach is the most efficient at removing smudges from the glass vial that might otherwise interfere with the optics. Following all sample analyses for a batch, a new sample of 20 NTU buffer will be measured and the results will be recorded on the laboratory datasheet.

The YSI Model 85 Conductivity/Dissolved Oxygen meter will be calibrated immediately prior to use in accordance with the manufacturer's suggested calibration procedures using a 1000 μS/cm specific conductivity standard. The sampling probe will be rinsed with DDI water by dipping the probe into a DDI water filled beaker three successive times followed by a DDI water rinse that is applied using a Nalgene squirt bottle. The "rinse" beaker will be rinsed and replenished with uncontaminated DDI water between samples. Prior to taking the first measurements, a 100 μS/cm specific conductivity standard will be analyzed and the results recorded to ensure the meter is holding calibration in the typical range of specific conductivity readings. The 100 μS/cm standard will be poured into a clean beaker and the conductivity probe shall be rinsed with the 100 μS/cm standard prior to submersion into the beaker. The results will be recorded on the laboratory datasheet. The temperature probe will be tested against a NIST traceable thermometer prior to the first use of the year and on a quarterly basis thereafter. The YSI Model 85 Dissolved Oxygen probe will be seated in the humid dissolved oxygen calibration chamber once the sponge has been moistened. The operator will go through the specified calibration procedure that includes the entry of the current altitude that is necessary for accurate dissolved oxygen calibration. The calibrated dissolved oxygen probe will be checked against a zero dissolved oxygen standard (Ricca Chemical # 9420-16 or equivalent) prior to field use, The zero oxygen solution shall be poured into a 100 milliliter polyproplyne graduated cylinder, the dissolved oxygen probe will be rinsed with zero oxygen solution and the oxygen probe will be inserted into the cylinder. The oxygen probe will gently be raised and lowered while remaining submersed in the zero oxygen solution until a stable dissolved oxygen reading is obtained. A zero oxygen solution measurement of less than 0.3 milligrams per liter shall be deemed acceptable and the meter will be considered properly calibrated. The YSI Model 85 temperature probe and the NIST

Table 15. Field Equipment Calibration Table

Equipment Name	Procedure and SOP Reference (Section or Appendix)	Frequency of Calibration	Acceptance criteria	Correction action	Person Responsible
Hanna pH meter and Beckman low ionic strength Star electrode	Section 9.4	Daily, prior to use. Post calibration at end of the day.	+/- 0.2 units	Recalibrate. If problem persists, ensure electrode is appropriately filled with filling solution	Field Coordinator
LaMottee 2020e Turbidimeter	Section 9.4	Daily, prior to use. Post calibration at the end of the day. *Performed by the CFB and the Volunteer Monitors.*	+/- 1.0 NTU	Recalibrate. If problem persists inspect/replace batteries and standard solutions.	Field Coordinator & Volunteer Monitors
YSI Model 85 Dissolved Oxygen	Section 9.4	Daily, prior to use. Post calibration at the end of the day. *Performed by the CFB and the Volunteer Monitors.*	+/- 0.3 mg/L	Recalibrate. If problem persists inspect/replace batteries, membrane and electrolyte.	Field Coordinator & Volunteer Monitors
YSI Model 85 Specific Conductivity	Section 9.4	Daily, prior to use. Post calibration at the end of the day. *Performed by the CFB and the Volunteer Monitors.*	+/- 5%	Turn off. Inspect/replace batteries. Turn on. Recalibrate if problem persists.	Field Coordinator & Volunteer Monitors
YSI 6600 Sonde Depth	Section 9.4	Daily, prior to deployment at each site.	+/- 0.12 m	Recalibrate.	Field Coordinator
YSI 6600 Sonde Dissolved Oxygen	Section 9.4	Daily, prior to deployment at each site.	+/- 2% of reading	Recalibrate. If problem persists inspect/replace batteries, membrane and electrolyte	Field Coordinator
YSI 6600 Sonde ORP and pH	Section 9.4	Daily, prior to deployment. Post calibration at the end of the day.	+/- 0.2 units (pH) +/- 20 mV (ORP)	Recalibrate. If problem persists, ensure electrode if appropriately filled with filling solution.	Field Coordinator
YSI 6600 Sonde Specific Conductivity	Section 9.4	Daily, prior to deployment. Post calibration at the end of the day.	+/- 5%	Recalibrate. If problem persists, replace filling solution and recalibrate.	Field Coordinator
YSI 6600 Sonde Chlorophyll a	Section 9.4	Daily, prior to deployment at each site.	+/- 20%	Recalibrate. If problem persists, clean lenses, replace standard solution and recalibrate.	Field Coordinator
YSI 6600 Sonde Turbidity	Section 9.4	Daily, prior to deployment. Post calibration at the end of the day.	+/- 0.2%	Recalibrate. If problem persists, clean lenses, replace standard solution and recalibrate.	Field Coordinator

Equipment Name	Procedure and SOP Reference (Section or Appendix)	Frequency of Calibration	Acceptance criteria	Correction action	Person Responsible
YSI Sontek ADV: flow meter	Section 9.4	As needed	+/- 1.0%	Replace batteries and clean transducers.	Field Coordinator
Li-Cor 1400	Appendix C	As needed	$R^2 > .95$ (with depth)	Return to manufacturer for re-calibration	Field Coordinator
Clinefinder	Section 9.4	As needed	+/- 0.5°C	Return to manufacturer for re-calibration	Field Coordinator

Based on EPA-NE Worksheet #14

thermometer will be submersed into a beaker filled with tap water at the ambient room temperature (between 15 and 20°C) and that contains a magnetic stirring bar. The beaker will be placed on a stirring plate, set on a low setting, and allowed to circulate to a homogeneous temperature for five minutes. Following the equilibration period, the temperature readings shall be recorded from both the Conductivity meter and the NIST certified thermometer. A temperature difference of <= 0.1°C between the two instruments shall be deemed acceptable (i.e. they fall within the manufacturer specifications) and no reconciliation action shall be taken. Should the temperature differ by greater than 0.1°C the YSI Model 85 shall be sent in for servicing through the manufacturer, Yellow Spring Instruments, or through the University of New Hampshire Instrumentation Center. The YSI 85 meter shall remain on for the entire day of sampling and, at the end of each sampling day, the specific conductivity will be analyzed on a 100 *u*S/cm standard while the dissolved oxygen will be measured at 100% saturation and measured in a zero oxygen solution. The post-sampling measurements will be recorded on a laboratory log sheet.

The YSI 6600 Sonde conductivity (using 100*u*S/cm standard), pH (using pH 7 and 5 buffers) ORP (using Zobel solution) and Turbidity (using zero, deionized water, and 100 NTU standards) probes will be calibrated prior to the sample trip. Depth (zeroing), Chlorophyll fluorescence (using zero blank) and dissolved oxygen (calibrating to 100% saturation) probes are calibrated directly before each deployment on-site. All calibrations are done according to the YSI 6600 User's Manual. The dissolved oxygen sensor shall also be checked against a zero blank at each site following "100% saturation" calibration but prior to deployment at each sampling site. The dissolved oxygen probe will be lowered into a zero oxygen solution (stored in a wide mouth polypropylene container) and the dissolved oxygen will be allowed to stabilize. A zero dissolved oxygen reading of less than 0.3 milligrams per liter shall be deemed acceptable and the oxygen probe will be considered properly calibrated. Upon return to the lab standard solutions are re-read for conductivity, pH, ORP and turbidity to check for drift. Readings are recorded in the instrument log and on the digital dataset contained in the logger. The YSI 6600 will be turned-on at the beginning of the day and will be powered down upon completion of the field sampling and following the collection of post-calibration measurements.

No calibration is require for the Li-cor 1400 data logger, underwater quantum sensor or deck cell as the sensors are NIST certified and we use this instrument to calculate relative light extinction with depth. Equipment performance can be ascertained by performing the regression analyses as described in the SOP for this instrument (Appendix C).

The YSI SonTek ADV velocity meter only requires occasional calibration when indicated by its internal diagnostics. Calibration, when necessary, is performed as directed in the user's manual.

9.5. Field Equipment Maintenance, Testing and Inspection Requirements

Field Equipment will be maintained tested and inspected in accordance with the manufacturer directions as listed below and as summarized in Table 16:

Equipment will be inspected prior to and following each use. The Hanna Instruments model HI 9025 pH meter will be inspected for any visible damage and for battery condition. Batteries will be replaced if the low battery indicator is visible. Prior to calibration and before storage, the pH

Table 16. Field Analytical Equipment Maintenance, Testing and Inspection.

Equipment Name	Activity	Frequency of activity	Acceptance criteria	Corrective Action **	Person responsible	SOP Reference
Hanna pH meter	Check Batteries; Visual Inspection	Daily	No visible damage to the meter, probe or cable.	Replace batteries; replace probe; send meter to manufacturer for servicing; replace cable.	Field Coordinator	Section 9.5
LaMotte Model 2020e Turbidimeter	Check Batteries; Visual Inspection	Daily	No visible damage to the meter.	Replace batteries; send meter to manufacturer for servicing	Field Coordinator and Volunteer Monitors	Section 9.5
YSI 85 * Temperature/ Conductivity/ Dissolved Oxygen meter	Check Batteries; Visual Inspection	Daily	No visible damage to the meter, probes or cable; oxygen membrane cap filled with solution.	Replace batteries; replace probe; send meter to manufacturer for servicing; replace cable.	Field Coordinator and Volunteer Monitors	Section 9.5
YSI 6600 Sonde and YSI 650 data logger	Check Batteries; Visual Inspection	Daily	No visible damage to the meter, probes or cable; oxygen membrane cap filled with solution.	Replace batteries; replace probe; send meter to manufacturer for servicing; replace cable.	Field Coordinator	Section 9.5
YSI Sontek ADV flow meter	Check Batteries; Visual Inspection	Daily	No visible damage to the meter, probe or cable	Replace batteries; send meter to manufacturer for servicing; replace cable.	Field Coordinator	Section 9.5
Li-Cor 1400 Irriadiance meter	Check Batteries; Visual Inspection	Daily	No visible damage to the meter, probes or cables	Replace batteries; send meter to manufacturer for servicing; replace cable.	Field Coordinator	Section 9.5
Clinefinder Temp/depth meter	Check Batteries; Visual Inspection	Daily	No visible damage to the meter, probe or cable	Replace batteries; send meter to manufacturer for servicing	Volunteer Monitors	Section 9.5

** The University of New Hampshire Instrumentation will repair instruments and cables when possible.

* Volunteer monitors will check the oxygen membrane prior to each use and replace the membrane as needed while the CFB Field Coordinator will replace the volunteer monitor oxygen membranes every three months.

Based on EPA-NE Worksheet #19

electrode will be inspected for dirt and scratches. The cables and connectors of the pH and temperature probes will also be inspected for damage. More filling solution (1 M AgCl) will be added to the pH probe if necessary. During storage and transport the pH probe will be protected by an attached storage bottle holding the appropriate storage solution.

The LaMotte 2020e Turbidimeter will be inspected for any visible damage and for battery conditions. Batteries will be replaced if the low battery indicator is visible. Prior to calibration and before storage, the Turbidity sample vials will be inspected for dirt and scratches. Damaged vials shall be discarded and replaced. The meter and vials will be protected by placing the instrument and accessories into the manufactures storage case between uses.

The YSI Model 85 Temperature/Conductivity/Dissolved Oxygen meter will be inspected for visible damage and for battery conditions. Batteries will be replaced if the low battery indicator is visible. Prior to calibration and before storage, the cable will be inspected for kinks and damage and the cable will be inspected to ensure the depth markings are clearly visible. The meter and cable will be stored in a designated storage container between uses.

The YSI 6600 Sonde and probes will be inspected for visible damage and the battery conditions shall be assessed in both the YSI 6600 Sonde and the YSI 650 data logger. Prior to calibration and before storage, the cable will be inspected for kinks and damage. All probes shall be inspected to ensure that they are securely anchored in the Sonde housing before use. The optical probes, turbidity and chlorophyll shall be inspected to ensure the optical surfaces are clear and that a sponge (wiper) is affixed to each probe. The pH probe will be inspected for scratches while the dissolved oxygen probe will be inspected to ensure no air bubbles have formed in the cell and to ensure that the membrane does not contain any folds or creases. All probes shall be inspected to ensure they are clean and to ensure that no growth has fouled any of the probe. Should either the YSI 6600 Sonde or the 650 data logger appear to have malfunctioned the instruments will be serviced by the Yellow Springs instruments service center. Likewise defective probes, if deemed cost effective, will be serviced through the YSI service center. Alternatively, replacement probes will be purchased and mounted on the YSI 6600 Sonde. Any such discrepancy or corrective action shall be recorded in the equipment maintenance log book.

The Li-cor 1400 data logger and probes will be inspected for visible damage and the battery conditions shall be assessed. Prior to use, both the deck cell and the submersible cell cables will be inspected for kinks and damage while both optical sensors shall be inspected to ensure that there is no fouling agent on either sensor. The submersible cell cable depth markings will be inspected and calibrated and any repairs will be recorded in the equipment maintenance log book.

The YSI Son-Tek ADV velocity meter and probe will be inspected for visible damage and the battery conditions shall be assessed. Prior to use, the probe cable will be inspected for kinks and damage and the flow sensor shall be inspected to ensure that there is no fouling agent on either sensor. as directed in the user's manual. The top setting wading rod will also be inspected for damage and the mounting screw will be tightened when necessary. Any repairs will be recorded in the equipment maintenance log book.

Prior to sampling and again before storage, the water quality sampling equipment (the plankton net, the Van Dorn and the integrated sampler) will be inspected for damage, integrity, cleanliness, blockages as well as full operation of moving parts and closing mechanisms. Lines and tubing will be inspected for damage, perforation and kinks. All depth markings on cables and lines will be checked for accuracy. Any discrepancies and repairs will be recorded in the field log book and copied to the equipment maintenance log book upon return to the lab.

9.6. Inspection and Acceptance Requirements for Supplies / Sample Containers

Sample bottles (characteristics listed in Table 14) will be purchased through Fisher Scientific or VWR International. Prior to sampling, the UNH Project Manager, UNH Lab Manager or a designated field team member will inspect the bottles for breaks or cracks and replace them when appropriate. Sampling teams will take two extra sets of bottles in case of cracks, breaks, loss or contamination discovered in the field. DDI water that will be used for field blanks will be placed in a 3 L opaque HDPE bottle and transported with other sample bottles to the field. For all containers, integrity, cleanliness and seal will be assessed in the field prior to use.

10.0 SAMPLE HANDLING, TRACKING AND CUSTODY REQUIREMENTS

10.1. Sample Collection Documentation

A combination of field log books, field data sheets and a consistent labeling protocol will help ensure sample authenticity, data integrity and project completion goals

10.1.1. Field Notes

The sampling team will complete field data log books and forms on-site at the time of sampling and/or when measurements are made. Field log books will provide the means of recording the data collecting activities performed during the investigation. As such, entries will be described in as much detail as possible so that persons going to the site could reconstruct a particular situation without reliance on memory.

The log books will contain the following information:

- Date / Time Arrived and Time Left
- Sampling Site ID (w/ Location and Coordinates)
- Full Names of Field Team Members
- Additional Persons Present
- Weather Conditions Throughout Visit
- General Observations
- Transportation Details
- Equipment Employed and Calibrations
- Measurements Made
- Photos Taken

In addition to the field logbooks, field data sheets will be used. One sheet will be used at each sampling location to ensure that all information specific to a particular site is archived on one standardized datasheet. There will be four standard datasheets employed in this study (see appendix E):

- CFB Lake Sampling Datasheet
- CFB Stream Sampling Datasheet
- Volunteer Stream Sampling Datasheet

Chain of custody forms will also be initiated in the field to document sample handling, preservation, transport and condition upon arrival to the lab.

All entries will be made in waterproof indelible ink. As data forms are considered an important part of the QA process no erasures or obliterations will be made. Instead, if an incorrect entry is made, the information will be crossed out with a single strike mark that is initialed and dated by the sampler. Field personnel will sign and date all forms when sampling is completed at the site.

10.1.2. Field Documentation Management System

All datasheets (described above) will be submitted upon return from the field or upon delivery of water quality and sediment samples to the UNH Laboratory Manager or UNH Project Manager. The data sheets will be compiled in three ring binders housed in the CFB laboratory and maintained by the Laboratory Manager. All requests for data, data sheets and logs for project personnel will be facilitated through photocopies of the original materials.

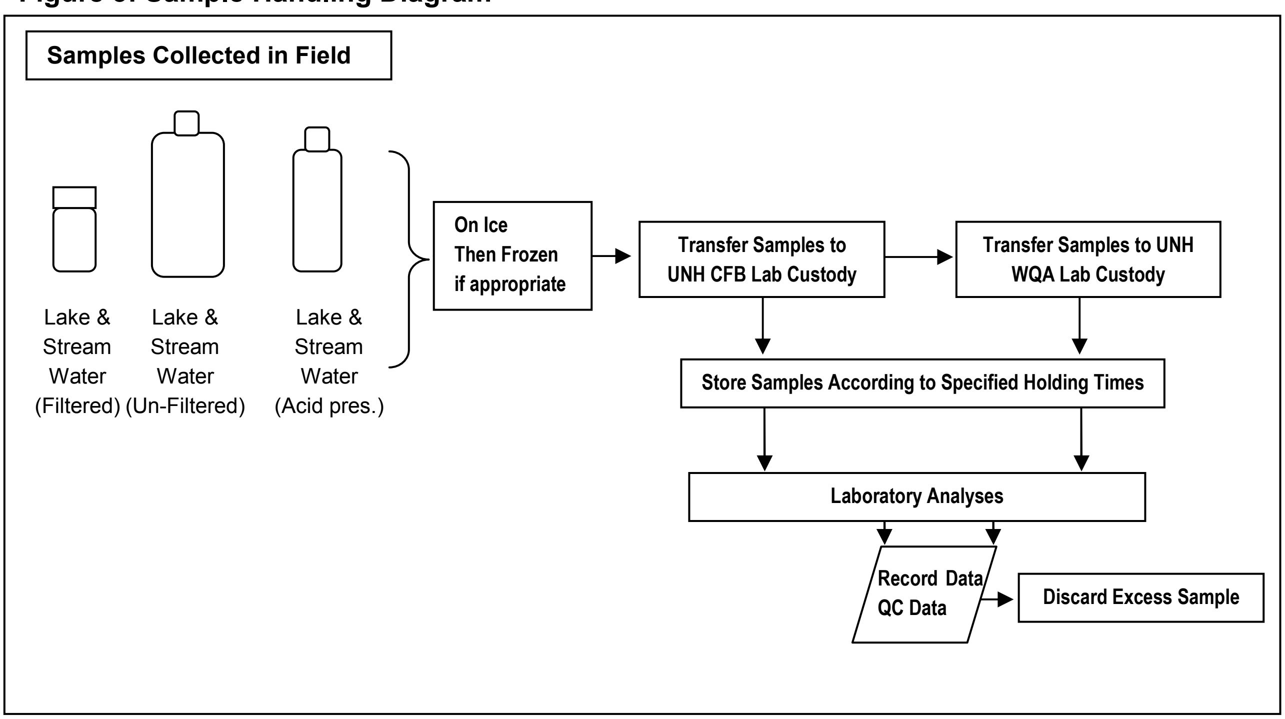
10.2. Sample Handling and Tracking System

All sample bottles will be labeled in the field (Figure 2) and entered onto a chain-of-custody (COC) form before leaving the site. All samples taken will be logged into the field log book before delivery and also in the sampling log book kept in the UNH Center for Freshwater Biology lab (Figure 3) upon arrival. All samples will be iced immediately after collection in the field and transported to the CFB lab where they will either be frozen in the lab freezer or refrigerated until analyzed, in accordance with SOPs, after log and database entry. Samples filtered and placed on ice in the field for dissolved nutrient and ion analysis will be frozen prior to transport to the WQA lab. Site names and ID numbers will be standardized by the UNH Project Manager (see Table 9 for Tributary site names and IDs).

Figure 2: Sample Label.

UNH Newfound Lake Watershed Assessment Project
Date:__/__/__ Collection Time__:__hrs Matrix: Water
Lake____ Stream____ Groundwater/Well____
Site Name/Number__________________ Depth_______
Acid Preserved Y N / Filtered Y N / Frozen Y N
Tests Requested:_______________________________
Sample Team:__________________________________

Figure 3: Sample Handling Diagram



10.3. Sample Custody

All samples for analysis will be directed to the Laboratory Manager at the UNH CFB Analytical lab. Water sample delivery will be documented on the appropriate Chain of Custody Form as well as into the laboratory sample MS Access database and sample log book. The CFB Laboratory Manager will inventory samples, review each field data form and contact the UNH Project Manager within 72 hours if unresolvable problems occur or if samples are missing. The sampling log book will be maintained by the CFB Laboratory Manager to document the custody of the water samples from the field to the analytical laboratory and will include the following:

1. Lake or stream name, station number, sample identification and GPS location,
2. Date and time the sample was collected,
3. Sample type: Grab, Composite or Seepage, Runoff
4. Sample matrix: Water,
5. Preservation technique used in each container,
6. The analysis requested,
7. Sampler name if signature found on COC form,
8. Date and time the samples were delivered to the lab,
9. Condition of sample: cold, frozen, broken, leaking, etc,
10. Storage or transfer location of sample with date and time.

The chain of custody for water samples is as follows: in the field, samples are the responsibility of, and stay with the sampling team. Once all of the samples have been collected they will be transported to the UNH Center for Freshwater Biology laboratory for analysis by a field team member. The CFB laboratory manager will record the date and time of arrival, will note the sample condition in the log, will update the chain of custody form and then freeze, refrigerate and/or arrange for transport to the proper lab. Samples for dissolved nutrients and selected ion analysis will be kept frozen and in the dark during building-to-building transport from the CFB lab to the WQA lab. Photocopies of the original chain of custody forms will be made and included with any samples delivered to another lab for completion. These forms will then be returned when sample analytical results are reported and filed with the original forms.

A sample project Chain of Custody Form can be found in Appendix E

Samples will be analyzed within their respective allowable holding times as listed in Table 14. Sample handling and custody procedures for the UNH Water Quality Analysis Lab are described in Section III of Appendix D.

11.0 ANALYTICAL METHODS REQUIREMENTS (FIELD AND FIXED LABORATORY)

11.1. Analytical Methods and SOPs

The analytical measurements that will be made are all based on existing standard methods (Table 17). The standard operating procedures (SOPs) for measurements made in the field are included in Appendix B. The SOPs for the nutrient analyses done by the CFB lab are in Appendix A and the SOPs for analyses done by the UNH WQA lab are listed in Appendix D. Maximum sample holding times are listed in Table 14. Footnotes at the end of Table 17 below indicate the requested laboratory turn-around times for analyses.

Table 17. Analytical Methods

Analyte	Matrix	SOP Appendix	Analytical Method Description And Method Citation
Field Measurements			
Temperature	Stream Water Lake Water	B.5	YSI Model 85 Temperature/Conductivity/Dissolved Oxygen Meter. Instrument Manual; Standard Methods 2550B
Conductivity	Stream Water Lake Water	B.5	YSI Model 85 Temperature/Conductivity/Dissolved Oxygen Meter. Instrument Manual; Standard Methods 2510B
Dissolved Oxygen	Stream Water	B.5	YSI Model 85 Temperature/Conductivity/Dissolved Oxygen Meter. Instrument Manual; Standard Methods 4500-O G.
Stream Velocity	Stream Water	B.7	YSI Son-Tek FlowTracker Handheld ADV Instrument Manual
Depth	Lake Water	B.8	YSI 6600 Sonde, Instrument Manual
Temperature	Lake Water	B.8	YSI 6600 Sonde / YSI Model 6560 Temperature/Conductivity Probe. Instrument Manual; Standard Methods 2550B
Dissolved Oxygen	Lake Water	B.8	YSI 6600 Sonde / YSI Model 6562 Dissolved Oxygen Probe. Instrument Manual; Standard Methods 4500-O G.
Conductivity	Lake Water	B.8	YSI 6600 Sonde / YSI Model 6560 Temperature/Conductivity Probe. Instrument Manual; Standard Methods 2510B
pH	Lake Water	B.8	YSI 6600 Sonde / YSI Model 6565 Combination pH/ORP Probe. Instrument Manual; Standard Methods 4500-H^+ B.
Oxidation Reduction Potential	Lake Water	B.8	YSI 6600 Sonde / YSI Model 6565 Combination pH/ORP Probe. Instrument Manual; Standard Methods 2580 B.
Turbidity	Lake Water	B.8	YSI 6600 Sonde / YSI Model 6136 Turbidity Probe. Instrument Manual.
Chlorophyll *a*	Lake Water	B.8	YSI 6600 Sonde / YSI Model 6025 Chlorophyll Probe. Instrument Manual.
Underwater Irradiance	Lake Water	C	Li-Cor 1400 Data Logger / LI-192 Underwater Quantum Sensor / LI-191 Deck Quantum Sensor Instrument Manuals.
Lab Analysis (Lake/Stream Water)			
Total Alkalinity[1]	Lake Water Stream Water	B.2	Low Alkalinity Titration to pH 4.5 ; Standard Methods 2320 B.
Total Phosphorus[3]	Lake Water Stream Water	A.3	Acid Digestion; Standard Methods 4500-P.E.
Dissolved Oxygen[1]	Lake Water	A.10	Winkler Titration via Std. Meth. 4500-O2 B.C.
Carbon Dioxide[1]		A.9	Titration via Std. Meth. 4500 CO2-C.

Analyte	Matrix	SOP Appendix	Analytical Method Description And Method Citation
pH[1]	Stream Water	B.1	Hanna Model HI 9025 Meter / Low Ionic Strength Probe. Instrument Manual; Standard Methods 4500H^+
Turbidity[1]		B.9	LaMotte Model 2020e Turbidimeter. Instrument Manual; USEPA 180.1
Ortho-Phosphate[2]		A.2	Standard Methods 4500-P.E.
Sodium[4]		D	Cations via ion chromatography and conductivity USEPA 300.1
Potassium[4]		D	
Magnesium[4]		D	
Calcium[4]		D	
Chloride[4]		D	Anions via ion chromatography w/ suppressed conductivity. USEPA 300.1
Sulfate[4]		D	
Nitrate[4]		D	

(based on EPA NE Worksheet 17 and 20)

[1] –As soon as samples are in lab and within 8 hours of collection (pH samples will be qualified as being analyzed in the laboratory within eight hours of sample collection).
[2] – Within 7 days of collection (orthophosphate samples that are not analyzed within 48 hours of sample collection shall be qualified as exceeding a two day holding time).
[3] – Within 30 days of collection.
[4] – Within 3 months of collection

11.2. Analytical Method/SOP Modifications

A weaker concentration of H_2SO_4 acid titrant (.002N vs .02N) than the standard method will be used to increase the sensitivity of the test for the low alkalinity waters expected to be encountered at Newfound Lake. Modifications to the other standard procedures listed above are not expected to be necessary. However, if Quality Assurance goals are not being met or if sample concentrations are not within typical range and minor corrective action or SOP modifications are warranted, the Laboratory Manager will be responsible to initiate corrective actions and inform the UNH Project Manager. It will be the responsibility of the UNH Project Manager to ensure the corrective action has been implemented correctly and reported to the NH DES Project Manager and QA Officer, and the EPA-NE QA Officer. Any major analytical method SOP modifications will be implemented only after consultation with NH DES and EPA-NE Quality Assurance Officers and will require a new revision of the project QAPP to be approved. All major and minor corrective actions will be documented and reported.

11.3. Analytical Instrument Calibration

Field instrument requirements for the pH meter, the YSI Model 85 temperature/ conductivity/dissolved oxygen meter, the Lamotte 2020e Turbidimeter, Li-cor 1400 photometer instrumentation, the YSI Son-tek ADV flow meter and the YSI 6600 Sonde and analytical probes are discussed in section 9.3. Spectrophotometers will be used in the analysis of phosphorus (Thermo Electron Spectronic model 1001+) and nitrogen (Varian Instruments model Cary 50 Scanning UV/Vis

Spectrophotometer) at the UNH CFB Laboratory. Before each use the spectrophotometer is inspected and the light path optics of the sample cuvette are cleaned with lens paper. At the beginning of each analytical run, a series of predetermined standards are used to generate a multi-point initial calibration curve. During use, calibration blanks are re-run to check for instrument drift after every ten sample readings and at the end of each sample run. If significant drift occurs (a difference greater than 0.001 Absorbance units), the instrument is recalibrated, blanked and the samples are re-run. The analytical balance (Denver Instruments Model A220) is tested for accuracy on a monthly basis using NIST traceable standard weights and recalibrated when needed. All calibrations are logged and any problematic occurrences are noted in the CFB instrument log book kept in the Laboratory Managers office. Equipment calibration procedures for the WQA lab are listed in Section V of Appendix D. Special care is taken in the use and disposal of the Zobell's solution used to calibrate the Redox probe on the YSI 6600 Sonde. All procedures are consistent with the UNH Office of Environmental Health and Safety Hazardous Waste Disposal Manual.

11.4. Analytical Instrument / Equipment Maintenance, Testing and Inspection Requirements

A Trimbal XRS Pro Global Positioning System receiver has a minimum horizontal accuracy of <1 meter and will be used to document the sampling locations. The TSC1 Asset Surveyor must be turned on for a minimum of 15 minutes before data collection begins, to ensure the current satellite almanac has been transmitted and received by the units. The TSC1 Asset Surveyor will be set to accept a maximum PDOP setting of 6, a minimum SNR setting of 39 dBHz and a minimum elevation setting of 15 degrees. Accurate readings shall be obtained when a minimum of four sattelites are transmitting data. If the aforementioned criteria are not met, a GPS point is not recorded. Sites are plotted and spatially checked using a Geographical Information System (GIS) computer mapping program (ArcGIS). Waypoints are measured in decimal degrees in accordance with New Hampshire Department of Environmental Services protocols and the GPS data will be converted to a degree, minute, second format for inclusion in any reporting output.

Field instrument requirements for the pH meter, the YSI Model 85 temperature/ conductivity/dissolved oxygen meter, the Lamotte 2020e Turbidimeter, Li-cor 1400 photometer instrumentation, the YSI Son-tek ADV, and the YSI 6600 Sonde and analytical probes are discussed in Section 9.4. Cleaning and decontamination procedures are discussed in Section 9.3. The spectrophotometers at the UNH CFB laboratory will be inspected (including internal diagnostic checks) and maintained according to the manufacturer specifications. The spectrophotometers will undergo a standard inspection/cleaning before the beginning of the sampling season (each spring) through the University of New Hampshire Instrumentation Center housed in the University of New Hampshire Chemistry Department. The analytical balance is kept clean and level and is inspected before each use. Full accuracy testing occurs on a monthly basis. All diagnostic and maintenance information will be entered into the CFB instrument log book. Equipment inspections and maintenance schedules for the WQA laboratory are described in Section IX of Appendix D. No problematic waste disposal issues are expected for maintenance, testing and inspection procedures described here.

11.5. Analytical Inspection and Acceptance Requirements for Supplies

All necessary supplies will be acquired before the start of the study and stock will be inspected and maintained throughout the course of the project by the Laboratory Manager. All stock reagents for the lab and field analyses are bar coded and logged into the UNH Chemical Environmental Management System (UNH CEMS) administered by The UNH Office of Environmental Health and Safety. The UNH CEMS system allows for maintaining chemical inventories and compliance. It also allows for tracking chemical stock and facilitating replacement when nearing the expiration dates. All working solutions are formulated, correctly labeled, stored in the proper container and required conditions, and handled according to the applicable method SOP. Before any field or lab use of reagents occurs they are inspected for container integrity, contamination and expiration date. WQA lab inspection schedules for consumables are listed in Section V of Appendix D.

12.0 QUALITY CONTROL REQUIREMENTS

Several types of quality control samples will be used to quantify data quality (Table 18). These include both samples collected in the field and those aliquotted in the laboratory (Table 8).

Table 18. Quality Control Samples

Quality Control Sample Type	Definition
Field Blank	A sample of distilled, deionized water that does not contain the measured analytes. The field blank is taken into the field and transferred into sample bottles in the same manner as routine samples (passing through sampling equipment). The field blank facilitates evaluating the entire measurement process from sample collection through lab analysis.
Bottle Blank	A sample of distilled, deionized water that does not contain the measured analytes. This blank is also taken into the field and transferred into sample bottles directly. This blank combined with results from the Field Blank and Laboratory Blank will help determine the source of contamination, if any.
Laboratory Blank	A sample of distilled, deionized water that does not contain measured analytes. The laboratory blank is used to check the cleanliness of the analytical process.
Replicate Samples	A second measurement made with a field instrument or analyzed from the same water or sample container. A replicate measurement will be made for each field measured or analyzed parameter.
Duplicate Samples	Two sub-samples of the same sample are collected in separate containers. The results from duplicate analyses are used to evaluate analytical or measurement precision. The duplicate sample is processed and analyzed in the identical manner as routine samples.
Sample Matrix Spike	A field sample for which a known concentration of the analyte(s) of interest has been added (sometimes called “audit samples”).

Section VII of Appendix D describes the quality control measures that will be used for analyses by the UNH Water Quality Analysis Laboratory.

12.1. Sampling Quality Control

The expected sample load associated with sampling and QC is shown in Table 19. Field duplicate samples will be collected on every sampling event. For example, in the case of the water/phosphorus budget sampling, at least 96 field duplicate and field blank samples will be collected throughout the study. This represents ~17% of the sampling load. Field blanks will be collected on each lake sampling event. Bottle Blanks will be collected on all trips and analyzed by the CFB lab. All QC samples will be blind to lab analysts as they will be labeled as they were regular site samples but noted as QC samples in the field log book. In addition, each volunteer monitor will provide at least 2 duplicate samples and one blank per year.

Table 19. Sample Load Breakdown

Analysis	# of Sampling Dates	# of Samples per Site	Total # of Locations Sampled (minimum)	Field Duplicates or Replicates (% of Samples QC'd)	Field and Bottle Blanks	Total # of Samples to Lab (or Total Readings Taken)
Field Measurements (Task IV Water/Phosphorus Budget)						
Stream Temperature	24	2	24	1 replicate / site (100%)	NA	Measured in field (1152)
Stream Conductivity	24	2	24	1 replicate / site (100%)	NA	Measured in field (1152)
Stream Dissolved Oxygen	24	2	24	1 replicate / site (100%)	NA	Measured in field (1152)
Stream Velocity	7	1	24	3 replicates / trip (13%)	NA	Measured in field (transects[1])
Field Samples (Task IV Water/Phosphorus Budget)						
Total Phosphorus	24	1	24	3 duplicates / trip (13%)	1 / trip (4%)	672
Turbidity	24	1	24	3 duplicates / trip (13%)	1/ trip (4%)	672
Field Measurements (Task V In-Lake Sampling)						
Depth Temperature Dissolved Oxy. Conductivity pH ORP Turbidity Chlorophyll	9	2	7	2 profiles / site (100%)	NA	Measured in field (profiles[2])
Underwater Irradiance	9	3	7	3 profiles / site (200%)	NA	Measured in field (profiles)

[1]- Usually, a minimum of three readings along the transect are taken for stream widths lower than 1 meter. Streams 1 meter to 2 meters in width are measured every 0.25 meters and streams greater than 2 meters are measured every 0.5 meters.

[2]- Profiles at deep sites are measured starting at 0.1 meters depth and the multi-parameter sonde is set to record approximately every 0.2 meters. Light profiles are taken at 0.1m, 0.5 m and every 0.5 meters thereafter.

Analysis	# of Sampling Dates	# of Samples per Site	Total # of Locations Sampled (minimum)	Field Duplicates or Replicates (% of Samples QC'd)	Field and Bottle Blanks	Total # of Samples to Lab (or Total Readings Taken)
Field Samples (Task V In-Lake Sampling)						
Total Phosphorus	9	3	7	2 duplicates / trip (10%)	1 / trip (5%)	216
Dissolved Oxy. (Winkler titration)	9	2	7	2 duplicates per trip (14%)	NA	144
Carbon Dioxide and Alkalinity	9	4	7	3 replicates / trip (11%)	NA	279
Zooplankton	9	1	7	1 replicate / trip (14%)	NA	72
Whole water Phytoplankton	9	2	7	2 replicates / trip (14%)	NA	144
Field Measurements (Task VI Near-shore Sampling)						
Temperature	6	1	30	1 replicate / site (100%)	NA	Measured in field (360)
Conductivity	6	1	30	1 replicate / site (100%)	NA	Measured in field (360)
Field Samples (Task VI Near-shore Sampling)						
Total Phosphorus	6	1	30	3 duplicates / trip (10%)	1 / trip (3%)	204
E. coli	6	1	30	3 duplicates / trip (10%)	1 / trip (3%)	204
Field Measurements (Task VII Stream Sampling)						
Stream Temperature	14	2	24	1 replicate / site (100%)	NA	Measured in field (672)
Stream Conductivity	14	2	24	1 replicate / site (100%)	NA	Measured in field (672)
Stream Dissolved Oxygen	14	2	24	1 replicate / site (100%)	NA	Measured in field (672)
Stream Velocity	2	1	24	3 replicates / trip (13%)	NA	Measured in field (transects[1])
Field Samples (Task VII Stream Sampling)						
Total Phosphorus	14	1	24	3 duplicates / trip (13%)	1 / trip (4%)	392

Analysis	# of Sampling Dates	# of Samples per Site	Total # of Locations Sampled (minimum)	Field Duplicates or Replicates (% of Samples QC'd)	Field and Bottle Blanks	Total # of Samples to Lab (or Total Readings Taken)
Turbidity	14	1	24	3 duplicates / trip (13%)	1/ trip (4%)	392
Field Measurements (Task VIII Nested Watershed Study)						
Temperature	5	1	12	1 replicate / site (100%)	NA	Measured in field (120)
Conductivity	5	1	12	1 replicate / site (100%)	NA	Measured in field (120)
Dissolved Oxygen	5	1	12	1 replicate / site (100%)	NA	Measured in field (120)
Field Samples (Task VIII Nested Watershed Study)						
Total Phosphorus	5	1	12	1 duplicate / trip (8%)	1 / trip (8%)	70
Soluble Reactive Phosphorus	5	1	12	1 duplicate / trip (8%)	1 / trip (8%)	70
Turbidity	5	1	12	1 duplicate / trip (8%)	1 / trip (8%)	70
pH	5	1	12	1 duplicate / trip (8%)	1 / trip (8%)	70
Calcium	5	1	12	1 duplicate / trip (8%)	1 / trip (8%)	70
Potassium	5	1	12	1 duplicate / trip (8%)	1 / trip (8%)	70
Magnesium	5	1	12	1 duplicate / trip (8%)	1 / trip (8%)	70
Sodium	5	1	12	1 duplicate / trip (8%)	1 / trip (8%)	70
Nitrate	5	1	12	1 duplicate / trip (8%)	1 / trip (8%)	70
Chloride	5	1	12	1 duplicate / trip (8%)	1 / trip (8%)	70
Sulfate	5	1	12	1 duplicate / trip (8%)	1 / trip (8%)	70

(based on EPA NE Worksheet 22a and 22b)

12.2. Analytical Quality Control

12.2.1. Field Analytical QC

For field measurements using the YSI Temperature/Conductivity meter, the YSI 6600 Sonde, the Lamotte 2020e Turbidimeter, and the Hanna pH meter, duplicate analyses will be performed on 100% of samples. If two readings are off by more than the values shown in Table 8, a third reading will be taken. Triplicate readings will be collected for the Li-cor 1400 irradiance logger to generate standard error data. If the resulting measurement is not within the acceptable range with one of the other samples, the UNH Project Manager will review the procedures in consultation with other personnel present in the field and decide on the outcome. The measurements may be discarded or one or more may be kept with qualification depending on the findings of the UNH Project Manager (see also Section 18 for validation flag coding and Section 19 for data usability discussion).

12.2.2. Fixed Laboratory QC

Additional QC samples will include lab blanks, lab duplicates, and lab fortified samples (matrix spikes, calibration samples and controls). One laboratory blank will be analyzed at both the beginning and end of each batch of samples analyzed at the CFB laboratory. 100% of the total phosphorus, turbidity, pH, alkalinity, dissolved oxygen and carbon dioxide samples will include laboratory duplicates. A minimum of 10% of the total phosphorus samples will be spiked. In-lab measured conductivity, pH and turbidity measurements as well as alkalinity and dissolved oxygen titrations will have 100% replicate measurements made. Ten percent (10%) of the phytoplankton and the zooplankton will be counted twice to ensure the biological data meet DQOs.

Table 20. Use of Quality Control Samples in the Lab for Nutrients

Analysis	Lab Blanks	Lab Duplicate Samples	Lab Fortified Matrix Spike Samples	Calibration Samples	Lab Fortified Blank (QC Control)
UNH CFB Lab					
Total P	**Reagent:** B & E* (>10%) **Instrument:** 1 every 10 spec readings	100% of water	4 per analytical batch (>10%)	5 standards / analytical batch	10%
Orthophpsphate	**Reagent:** B & E* (>10%) **Instrument:** 1 every 10 spec readings	100% of water	2 per analytical batch (>10%)	5 standards / analytical batch	10%

Analysis	Lab Blanks	Lab Duplicate Samples	Lab Fortified Matrix Spike Samples	Calibration Samples	Lab Fortified Blank (QC Control)
UNH Water Quality Analysis Lab (Ion Chromatography Analysis)					
Sodium	**Reagent:** B & E* (>10%) **Instrument:** 1 every 10 IC readings	10%	NA	5 standards / analytical batch	10%
Potassium					
Magnesium					
Calcium					
Chloride					
Sulfate					
Nitrate					

(Based on EPA-NE Worksheet# 24a)

* B & E denote the beginning and end of an analytical run.

13.0 DATA ACQUISITION REQUIREMENTS

It is expected that the majority of the data produced directly by this project will serve to develop the primary findings of the Newfound Lake water/phosphorus budget, the in-lake water quality study and the nested watershed study. Secondary data historically collected by the NHDES and the UNH CFB will be used to perform comparisons and to support project conclusions. Additional secondary data will be used to perform watershed delineations and to analyze land use variations among the sub watershed. Secondary data and their uses are described in Table 21.

Table 21. Non-Direct Measurements Criteria and Limitations Table

Non-direct Measurement (Secondary Data)	Data Source	How Data will be Used	Limitations on Data Use
Newfound Lake Stream Study Data	University of New Hampshire Center for Freshwater Biology. Unpublished data: June 2006 – May 2007.	Develop phosphorus budget for Newfound Lake using additional data collected as part of this QAPP. DES indicated the historical data, using comparable DQO, were acceptable for the phosphorus budget.	Comparable DQO requirements and QA protocols. Sampling sites correspond to the sites outlined in Table 9. Any differences will be noted and the data qualified.
Newfound Lake Phosphorus Budget	Newfound Lake Region Association publication: Newfound Lake: Lake and Tributary Health (1996)	Comparison purposes.	Comparable DQO requirements and validated performances to this study; otherwise will notate difference and qualify the data.
Newfound Lake Dam (outlet) discharge, lake stage, rainfall and temperature data	New Hampshire Department of Environmental Services	Provide discharge values and climatological data used in the Newfound Lake water/phosphorus Budget.	Data will be used to provide estimates for the Newfound Lake phosphorus budget.
Phosphorus dry deposition estimates	UNH Hydrology Department and Civil Engineering Department	Calculations used in the Newfound Lake water/phosphorus budget	Data will be used to provide estimates for the Newfound Lake phosphorus budget.
Climatological Data	National Oceanic and Atmospheric Administration National Climatic Data Center: Alexandria and Massabessic Lake stations.	Comparison purposes; lake evaporation data will be needed for the Newfound Lake water/phosphorus budget	Precipitation and temperature data will be used to validate data collected at the Newfound Lake Dam and will provide estimates for the Newfound Lake phosphorus budget.

Non-direct Measurement (Secondary Data)	Data Source	How Data will be Used	Limitations on Data Use
Water Quality Data: Total Phosphorus, Secchi Transparency, pH, Specific Conductivity. Alkalinity, DO, selected ions	NH DES, UNH CFB , UNH Lakes Lay Monitoring (historical and recently collected)	Comparison purposes	Comparable DQO requirements and validated performances to this study; otherwise will notate differences and qualify the data.
Bathymetric maps, topographic maps orthophotos, GIS coverages	NH DES, NH Fish and Game and UNH GRANIT GIS data coverages.	Sub-watershed delineations: land cover assessments: Sample location mapping.	Date of data collection and map creation. GIS metadata standards.

(Based on EPA-NE Worksheet #25)

14.0 DOCUMENTATION, RECORDS AND DATA MANAGEMENT

14.1. Project Documentation and Records

Project documents and records that will be generated by this project are listed in Table 22. The UNH Project Manager has final responsibility for all documentation and records. All documentation and records will be located in the UNH CFB laboratory office.

Table 22 Project Documentation and Records.

Sample Collection and Documentation Records	Field Analysis Records	Fixed Laboratory Records	Data Assessment Records
Field log books	Field data sheets	Lab data sheets	Documentation of corrective actions for field sampling, field analysis and fixed laboratory analysis
Field data sheets	Field instrument log book	Instrument log book	
Site Maps		Raw and tabulated results data	
Digital Photographs		Contract lab data results (raw, tabulated and/or digital)	UNH FBG Lab QA/QC documentation and reporting
Chain of Custody Record		Chain of Custody Record	QA/QC section in preliminary reporting

14.2. Field Analysis Data Package Deliverables

Field analytical measurements will be generated on-site. Measurements will be recorded on field data sheets or in the case of multiparameter Sonde data, digitally onto the computer data logger, and these data will be transferred to an electronic spreadsheet (MS Excel) that is a part of the project-specific electronic database system. Entries into the spreadsheet will be compared against the field sheets by a second person as a quality check before it is appended to the project database.

14.3. Fixed Laboratory Data Package Deliverables

The UNH CFB Laboratory will provide the UNH Project Manager with a copy of the sample log book (see Section 10.3), sample custody forms and a computer generated form which includes the laboratory results, the sample number, matrix, collection date and time, log in date and time, analysis completion date, sampling location, the field technician/sampler and a summary of the QA/QC data. The Water Quality Analysis Laboratory will provide the UNH Project Manager with a data package as described in Section VI of Appendix D.

14.4. Data Reporting Formats

Field and lab entries will be made in indelible ink. No erasures or obliterations will be made. Instead, if an incorrect entry is made, the information will be crossed out with a single strike mark which is signed and dated by the sampler or analyst. Field personnel will sign and date all forms when sampling is completed at the site. Laboratory personnel will date and sign all lab analytical data sheets. Field and laboratory data will ultimately be recorded into a password protected computer database (Microsoft Access). All computer datasets will be checked twice for entry or transcription errors before the data are combined into the final project database.

14.5. Data Handling and Management

<u>Data Recording:</u>

Results from field measurements are written onto field data sheets and field logs (see Section 10.1.1 for field notes taken). Results from profiling are directly recorded into digital files captured by the computer data logger. Results from laboratory analyses at the UNH CFB lab are written onto parameter-specific lab data sheets that are kept in three ring binders in the lab. The results of the analytical measurements are then entered into the computerized (Microsoft Access) laboratory database. The date of completion of laboratory analysis is listed in the sample log book and entered into the computerized database.

Upon receipt of the UNH Water Quality Analytical Lab data deliverables the Lab Manager will update the sample lab book to reflect the date of analyses for those samples.

<u>Data Transformations / Data Reduction:</u>

Data will be analyzed statistically in spreadsheet or statistical analysis programs (see Software below) for ranges, means, medians, standard deviations, standard error, and minimum and maximum values for each sampling event. Calculations used to determine analyte concentrations are listed in the SOPs located in the Appendices. QA data will be analyzed using the formulae listed in Section 7.0 of this QAPP.

<u>Data Transfer / Transmittal:</u>

The UNH CFB lab database is designed to generate lab analysis reports, data summaries and raw data tables. Upon receipt of the Water Quality Analytical Lab data deliverables, and after checking the accompanying QA/QC summary, the CFB Lab Manager will update the sample analytical dataset. All results will be transmitted to the Project Manager for inclusion into the project database.

The master project database will be maintained by the UNH Project Manager in a Microsoft Access database file. All data entry will be done in a separate Excel spreadsheet checked twice and reviewed by the UNH Project Manager before being appended to the master database spreadsheet.

Data Analysis:

The following software will be used in data analysis: Excel spreadsheet software (Microsoft), Sigma Plot analysis and graphing software (Systat Software Inc.). SPSS statistical analysis software (SPSS Inc.) Lakewatch Software (Scientific Software Group). ArcGIS (ESRI) software will be used to create location maps.

Analytical Models:

Common lake trophic analysis models authored by Dillon, Rigler, Hutchinson and Reckow (and colleagues) will be run to find the best predictive model for Newfound Lake nutrient loading and chlorophyll response.

Data Assessment:

Field data forms will be reviewed and signed by the sampling team before delivering water samples to the UNH Center for Freshwater Biology Laboratory. Upon arrival at the UNH CFB laboratory the Lab Manager will review the data sheets for completeness, inventory samples and review Chain of Custody Forms. Any unresolvable errors or omissions regarding samples or field data will be documented and the UNH Project Manager will be notified within 24 hours.

The UNH CFB Lab Manager will review all lab notebooks and computerized data after QC checks have been completed to determine whether the data are acceptable (if the DQOs are not reached the samples will be rerun). After the entry of each sampling event, the data will be assessed using summary statistics, mean, median, standard deviation and coefficient of variation to identify potential outliers and possible measurement errors. Questionable data will be flagged with a code (described in section 18.1) identifying the concern (See also Sections 17 and 18.0 on Data Verification and Validation for additional project data assessment procedures).

14.6. Data Tracking and Control

Data Tracking

As this is a small project with limited scope and a small data set, there is no need for an extensive data tracking system. All data will be analyzed on the University of New Hampshire Durham Campus and all sample transport will be performed by the UNH CFB field technicians. The CFB Lab Manager will assure all samples taken in the field were accounted for and the sample dataset is complete through checks using the sample log book.

Data Storage, Archival, and Retrieval

In addition to the aforementioned project deliverables, hard copy and digital data summaries and listings will be made available to the Newfound Lake Region Association, NHDES and EPA New England in any form(s) requested. However, all data sheets and generated digital data will be in the final custody of the UNH Project Manager, who will make sure that all hard copies and electronic copies are stored in an organized fashion. Hard copies of all information used and generated for this project will be stored by the UNH Project Manager for at least 5 years. Electronic copies of the following items: raw data, data summaries, field notes, statistical results and final report will be stored on the computer of the UNH Project Manager and on a CD backup system indefinitely.

Data Security

Although all data are public information, the project data package will be kept in a limited access area available to the UNH Lab Manager and the UNH Project Manager. All computer data base files are password protected.

15.0 ASSESSMENTS AND RESPONSE ACTIONS

15.1. Planned Assessments

In order to determine that field sampling, field analysis and laboratory activities are occurring as planned, field staff and laboratory personnel shall meet, after the first sampling event, to discuss the methods being employed and to review the quality assurance samples. At this time all concerns regarding the sampling protocols and analysis techniques shall be addressed and any changes deemed necessary shall be made to ensure consistency and quality of subsequent sampling. Any changes in field or lab methods or SOPs will be submitted to NHDES and EPA New England for approval. Assessment frequencies and responsible personnel are shown in Table 23.

Table 23. Project Assessment Summary.

Assessment Type/Activity	Frequency	Responsibility for Assessment	Responsibility for Responding to and Initiating Corrective Actions of Assessment Findings	Responsibility for Monitoring Effectiveness of Corrective Actions
Field Sampling Audit	At beginning of study	UNH Project Manager	UNH Project Manager	UNH Project Manager
Field Analytical Audit	At beginning of study	UNH Project Manager	UNH Project Manager	UNH Project Manager
Field Data Verification	After each field trip	UNH Project Manager	UNH Project Manager	UNH Project Manager
UNH CFB Laboratory Analytical Data Verification / Validation	Soon after each analytical batch run	CFB QA Officer	CFB Laboratory Manager	CFB Laboratory Manager
UNH CFB Laboratory Services Audit	Annually	CFB QA Officer	CFB Laboratory Manager	CFB Laboratory Manager
UNH WQA Laboratory Services Audit	Quarterly	WQA Laboratory Manager	WQA Laboratory Manager	WQA Laboratory Manager
QAPP Review	Annually	UNH Project Manager	UNH Project Manager	UNH Project Manager

(Based on EPA-NE Worksheet #27b)

15.2. Assessment Findings and Corrective Action Responses

Field Sampling:

QAPP deviations and project deficiencies determined during the field sampling assessment will be evaluated for source of deviation and corrected with verbal communications in the field and documentation in field log books. Any necessary written/structural changes will be made through a revision of the SOP for that activity. Field sampling activities will be monitored to determine compliance.

Field Analytical:

QAPP deviations and project deficiencies determined during the field analytical assessment will be evaluated for source of deviation and corrected with verbal communications in the field and documented in field log books. Any necessary written/structural changes will be made through a revision of the SOP for that activity. Field analytical activities will be monitored to determine compliance.

UNH CFB Laboratory Services Fixed Laboratory:

QAPP deviations and project deficiencies determined during the CFB lab fixed laboratory assessments will be addressed immediately. Duplicates, blanks and critical range tables will be checked with data to determine if sources of error exist. Any deviations in results will be addressed in both written and verbal formats, and future sampling will be monitored to verify that compliance is reached.

UNH WQA Laboratory Fixed Laboratory:

QAPP deviations and project deficiencies determined during the WQA lab fixed laboratory assessments will be addressed immediately. Duplicates, blanks and critical range tables will be checked with data to determine if sources of error exist. Any deviations in results will be addressed in both written and verbal formats, and future sampling will be monitored to verify that compliance is reached.

15.3. Additional QAPP Non-Conformances

Corrective actions will be implemented any time that deviations or errors are noted in field and laboratory work during the project. For example, on completion of an analytical batch run (or soon after) the lab technician will review the results of the run with the laboratory QA officer and any samples not meeting the QAPP requirements will be re-run. Any significant corrective actions (i.e.: change in sampling strategy, change in field or lab methods or SOPs, change in quality control samples) will require the final approval of the UNH Project Manager. Any changes in field or lab methods and SOPs will be reported to NHDES and EPA New England in an annual QAPP review update.

16.0 MANAGEMENT REPORTS

Interim progress reports will be provided to NHDES by the Project Manager using the project reporting form. The final report submitted to NHDES will be written in accordance with the 319 Program Final Report Guidelines. The UNH Project Manager will provide the NHDES Project Manager with the appropriate information required for these reports.

As stated in the previous section, reviews of lab and field data will be an ongoing and frequent process. QA data will be included in the Annual QAPP review, any data summaries, project updates and project reports. A QA/QC section will be generated for both the interim and final project reports and will contain:

- An overview of the QA/QC program,
- All data quality assessments, corrective actions and their results,
- Attainment or non-attainment of project data quality objectives, completeness of field sampling and lab analyses, and project task achievement summary. All will include the appropriate explanation for attainment or non-attainment,
- Verification and validation summaries and,
- Any limitations on the use of the data related to reconciliation of DQOs.

17.0 VERIFICATION AND VALIDATION REQUIREMENTS

Verification is the review of the sampling and analysis data to see if data required for the completion of the project are available. Validation is the process to assess and document the performance of the field sample collection process and the performance of the lab analytical process. Validation assesses not only compliance with method, procedure, and contract requirements, but also compliance with QAPP-specific requirements. Data of known and documented quality will be provided by these examinations.

Data verification will occur under the supervision of the UNH Laboratory Manager/Quality Assurance Officer through the detailed examination of data sheets and raw data to check for transcription errors, calculations, measurement within calibration range, compound identification and completion. Data validation will consist of an assessment on all field and lab data to check that they meet the data quality objective criteria set forth in this QAPP and specifically listed in Sections 7, 9, 10, 11 and 12. Any discrepancies will be brought to the attention of the UNH Project Manager for action.

18.0 VERIFICATION AND VALIDATION PROCEDURES

This section of the QAPP describes the process that will be followed to verify and validate project data.

18.1. Verification Procedures

Field Data

After each CFB team sampling trip and when volunteer data sheets are submitted, verification reviews for field-based activities are conducted by the UNH Project Manager to ensure data are collected in accordance with this QA Project Plan and documented SOPs. This is achieved by confirming:

- Sampling strategy and sampling methods were followed.
- Field equipment was calibrated and documented on data sheets.
- Data are appropriately documented on the field data sheets.
- There was appropriate reconciliation of documentation errors during calibration and field activities.
- Samples were collected into proper containers, preserved (if necessary) and stored properly.
- The transfer of custody of each water sample is verified correctly on the Chain of Custody Form.
- Any deviations or deficiencies to the above and any resultant corrective actions were documented correctly.

Laboratory Data

Before analytical data results are transmitted from the labs to the UNH Project Manager the respective lab manager will insure complete verification through documentation (memorandum) included with the laboratory data package:

- Samples were received in the proper condition.
- The appropriate methodology was used.
- Instrumentation was functioning properly.
- Instrumentation was calibrated according to QAPP stated schedules.
- Samples were analyzed within the specified holding times.
- All samples delivered were accounted for and analyzed.
- There was appropriate reconciliation of documentation errors during calibration and analysis.
- Any deviations or deficiencies to the above and any resultant corrective actions were documented correctly.

At the conclusion of the project a verification review will be conducted by the Program Manager to ensure consistency between field samples collected, laboratory samples submitted and laboratory data received.

18.2. Validation Procedures

Validation reviews will be ongoing throughout the project following sampling events (staff and volunteer), during and following analytical batch runs, following field and lab data entry, before any data analysis and at the completion of the project prior to final reporting.

Field Data

Validation reviews for field-generated data are conducted at the end of each sampling day, where the UNH Project Manager reviews calibration data and field sampling data (temperature, specific conductivity and in-lake profiling data) to ensure data are within the anticipated limits. The UNH Project Manager screens the data, and discusses any potential outliers with field technicians and/or volunteers. The Program Manager validates the data collected for that particular day by signing the data sheets at the conclusion of each sampling day.

Validation reviews for field-generated data are also conducted throughout the project as data entry activities are conducted and more complete data sets can be examined. The UNH Project Manager screens the data, and discusses any potential inaccuracies with field technicians and/or volunteers before appending data to the project database.

Laboratory Data

Validation reviews for laboratory-generated data are conducted during each batch run by UNH CFB Laboratory technicians under the supervision of the CFB Laboratory QA Manager as previously described. Before analytical data results are transmitted from the labs to the UNH Project Manager the respective lab manager will insure complete validation through documentation (memorandum) included with the laboratory data package. After transmittal of laboratory data to the UNH Project Manager, a validation review is conducted for any potential outliers and blind sample results are checked for meeting acceptance criteria. The UNH Project Manager will contact the respective laboratory QA manager to reconcile any inaccuracies.

Validation will be achieved by confirming:

- All analytes were quantified within the calibration range.
- The analyses met the acceptance criteria for duplicates, spiked samples, control samples, and blanks.
- For any deviations or deficiencies to the above the data were flagged.
- Any nutrient samples that were frozen prior to analysis shall be identified.
- Any resultant corrective actions were documented correctly.

18.2.1. Validation Flagging Codes

Questionable data will be flagged with a code that identifies the nature of the concern. The first digit of the flag code will be: F - field or L - laboratory. Laboratory flags will be coded with a second digit to indicate one of the following:

1. QC blank samples were more than the acceptable value for blanks for that analysis. All samples in the batch will be flagged (generally would have caused a batch re-run at the time of analysis).
2. QC spiked samples were more than the acceptable value for percent recovery. All samples in the batch will be flagged (generally would have caused a batch re-run at the time of analysis).
3. QC reference samples were more or less than the acceptable recovery value range. All samples in the batch will be flagged.
4. The difference between lab duplicate sample results for a collected sample was greater than the acceptable range or the difference between field duplicate samples did not meet the acceptable RPD.
5. The single sample value is more than two times the standard deviation of the batch.
6. The sample value is unacceptably high or low (in terms of analytical range) and this datum should not be used.
7. Results of the sample are within all tolerances but there was evidence of possible sample contamination or the sample bottle was not returned intact.
8. A qualifier (FR) shall be used to document all nutrient samples that were frozen prior to analysis but that otherwise meet the QC criteria, inclusive of holding time, outlined in this QAPP.

Note that codes 1-3 should trigger a batch re-run, codes 4 and 5 should trigger a sample re-run and code 6 may trigger a sample re-run after a dilution of the sample.

19.0 DATA USABILITY / RECONCILIATION WITH PROJECT QUALITY OBJECTIVES

Upon completion of each sampling event and receipt of water chemistry results from the UNH labs, determinations for precision, accuracy, and completeness will be made by the UNH Project Manager. If necessary, corrective actions will be implemented as described in previous sections. If data quality indicators do not meet the project's specifications, those data will be appropriately flagged and a notation shall be included with any tabular data listings. Data that are deemed unusable or not meeting the minimum DQO specifications documented in Sections 7.0 and 12.0 of this report shall not be used in analysis. The cause of failure will be evaluated. If the cause is found to be equipment failure, calibration and/or maintenance, techniques will be assessed and corrected. If the problem is found to be sampling error, sampling methods will be reviewed with all project participants and retraining will occur when necessary. Any revisions in sampling methodology, sample processing, or analytical methods will be submitted to the State and EPA quality assurance officers through a memorandum for approval.

If completeness, representativeness, and comparability goals are not met, then a re-sampling visit will be scheduled if time permits and if it is within project scope and budget. If after all attempts to re-sample and repeat analysis on samples fail and the data set is limited, and questionable data must be used, they will be used for reference only, and they will be footnoted as questionable and not meeting the projects original DQOs. Any decisions made regarding the usability of the data will be left to the UNH Project Manager. However the UNH Project Manager may consult with project personnel, the NH DES Project Coordinator, or with personnel from EPA-NE, if necessary. The UNH Project Manager will ultimately be responsible for determining the acceptability of data and/or for determining if re-sampling is needed. Any limitations on the data used will be detailed in the interim and final project reports, as well as anytime the data set is provided to other data users.

20.0 REFERENCES (FOR QAPP AND APPENDICES)

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